MANEY

An Investigation of the Stresses in Cantilever Flat Slabs

Theoretical and Applied Mechanics

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AN INVESTIGATION OF THE STRESSES IN CANTILEVER FLAT SLABS

BY

GEORGE ALFRED MANEY

C. E. University of Minnesota, 1911

THESIS

Submitted in Partial Fulfillment of the Requirements for the

Degree of

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IN THEORETICAL AND APPLIED MECHANICS

IN

THE GRADUATE SCHOOL

OF THE

UNIVERSITY OF ILLINOIS

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

GEORGE ALFRED MANEY

ENTITLED AN INVESTIGATION OF THE STRESSES IN CANTILEVER FLAT SLABS

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN THEORETICAL AND APPLIED MECHANICS.

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Recommendation concurred in:

Committee on Final Examination

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VIEW OF [illegible] IN GENERAL LABORATORY

Figure 1.

AN INVESTIGATION OF THE STRESSES IN CANTILEVER FLAT SLABS.

I. INTRODUCTION.

1. Preliminary. There has been much disagreement between the designers of the various flat slab systems now in use, with regard to the fundamental bases for design. The more conservative engineers have a deep seated distrust of the flat slab analyses advanced by mathematical elasticians of the past and present. Insufficient experimental data have so far been obtained for the verification of any theory known to the writer.

Most designers and investigators of flat slabs seem to follow one of two general lines in their study of the problem, viz; the consideration (a) that a slab is made up of multiple beam systems or (b) that slab action is independent of beam action and that any analysis of slab action must be built up from the ground without reference to beam analysis. Most conservative designers prefer to consider any flat slab as composed of two or more superimposed beams which between them carry the total load on the floor to the columns. Naturally, analyses based on beam action find favor with many practical designers. A good example of this method is the Acme System which is owned by the Condron Co. of Chicago. Their slab has a method of construction similar to that of the Corr-Plate System, mentioned later, although designed on entirely different principles. Several of theflat slab systems now widely used have a method of design which is based on flat slab action. A good example of these is the Corr-Plate System which assumes that strips of different

width in each direction have different coefficients of bending moment. The values of these coefficients have been approximately determined by the owners of this system from the results of tests made by them on a rubber model under load.

The "Mushroom" system used by Mr. C.A.P.Turner has been given much notoriety in the technical press by consistent disagreements of its owner with every other authority in regard to the coefficient of the bending moment for which the steel in flat slab floors should be computed. An article by Mr. Nichols regarding the statical limitations of flat slab action, which is printed in the Proceedings of the American Society of Civil Engineers, gives a very interesting discussion of the problem and makes the coefficient of bending moment of(1/50) WL, as assumed by Mr. Turner, seem incorrect.

Another point on which there has been some disagreement is the relative distribution of stresses and deformations in the steel and in the concrete over any section of the floor slab which may be cut. Some authorities hold that the stress in the concrete at any point is governed by the percent of steel and the amount of stress in the steel at that corresponding point. Others think that the entire resisting moment on a section consists of a couple between the total concrete and steel stresses on this section and that there is no particular relation between the steel stresses and the concrete stresses at any given point along this section.

A great many points with regard to flat slab action are at present subjected to a difference of opinion on the part of designers. It is hoped that the series of tests of which these here included are a part, will help to clear up some of these points.

2. Acknowledgement. These tests are made as part of a series of tests for the purpose of clearing up some much disputed points in flat slab action and were conducted as a part of the research work of the U. of Illinois Engineering Experiment Station. They were planned and carried out under the supervision of Prof. A. N. Talbot who has suggested the design of the slabs most suited to the investigation of the points in question and has made many helpful criticisms. The test specimens were made under the supervision of Mr. D. A. Abrams of the Experiment Station, and to him and Mr. Slater of the Experiment Station, credit is due for helpful suggestions and criticisms during the progress of the tests. Mr. H. R. Thomas and Mr. W. Julian Montgomery have lent efficient assistance during the making of the tests. To these and other members acknowledgement is here made for assistance and advice.

3. Scope of Tests. These tests were designed principally to determine;(1) the correct method of equating the resisting moment developed by a slab to the bending moment developed by the applied load, and(2);the exact relation between the deformations along any radial direction with regard to the center of the column and those perpendicular to any radial section , which deformations will be called circumferential in the subsequent discussions.

In addition to these two principal points it was hoped that some light would be thrown on other much discussed points such as ;(1)the relation between steel and concrete stresses throughout the same section;(2) the effect of column cap diameter;(3) the effect of a drop; (4) the effect of lateral deformation in the con-

crete or of Poissons Ratio; (5) the relation between the stress in the rods of a rectangular belt and that in circular hooped rods cutting a radial section at the same point. It is hoped that some of the results of these investigations will be applicable to commercial design and that the relation between the stresses in a radial and in a circumferential direction will be definitely determined.

4. Notes on Flat Slab Action.

As has been said in the introduction, there exists much difference of opinion between the various owners, designers and authorities on, flat slab floor systems of reinforced concrete, with regard to the fundamental bases for correct design.

Prominent among those authorities who advocate the application of an exact flat plate analysis as opposed to the approximate method of analysis by division into beam strips, stands Dr. E. H. Eddy, former Professor of Mechanics at the University of Minnesota. In the "Minnesota Engineer" of 1907 he published a highly mathematical series of flat plate analyses for various different cases of loading and support, and homogeneous material.

In 1913, Dr. Eddy published a book on the subject of flat slab floors which is an application of his work before referred to, to the problem of reinforced concrete girderless floors. One of the points upon which much emphasis is laid in this treatise concerns the effect of Poissons ratio in the concrete, which is the ratio of the deformation of the concrete in a direction at right angles to the direction of the stress to the deformation in the same direction. A very considerable increase in the strength of the slab is claimed for reasons based on this action. It is thought doubtful whether anything except the modulus of elasticity is affected by the action of this lateral deformation and it does not seem possible that such action of the concrete would make possible any decrease in the amount of steel required except by increasing in some way the effective depth of the slab. It seems that in equating the resisting to the bending moment, all the steel cutting the

resisting section has the same maximum stress regardless of its direction or form. The results of the tests made here indicate that at the same point in different directions we, in general, have different stresses and that along any section there is well defined variation in the value of the stresses existing. The hoops used over the column tops upon which the various belts of rods are supported are considered as effective in resisting the bending as the other steel. It is not seen how some of the hoops which are located near the neutral axis at which depth no stress is supposed to exist, can be considered as at all effective. The design formulas of Dr, Eddy indicate that a greater bending moment exists in the direction of the belts of rods having the longer span and that in these belts more steel is required. The results of several tests, including one described by Dr. Eddy himself in the January, 1914 number of the A. S. C. E. Proceedings, show that such is not always the case. A percent of steel not greater than .5 is also advocated. The tests included in this thesis and in that of Mr. Bells* show that the slabs therein described which have in every case more than .5% of steel regardless of how the percent is figured, have deformations in the steel which are from two to three times larger than those in the concrete over a diametral section.

The points brought up by Dr. Eddy in his discussion are important ones, and much more experimental evidence than is available at the present time must be had before anything very positive can be decided concerning them.

*An Investigation of the Stresses in Cantilever Flat Slabs, by W. C. Bells, 1913.

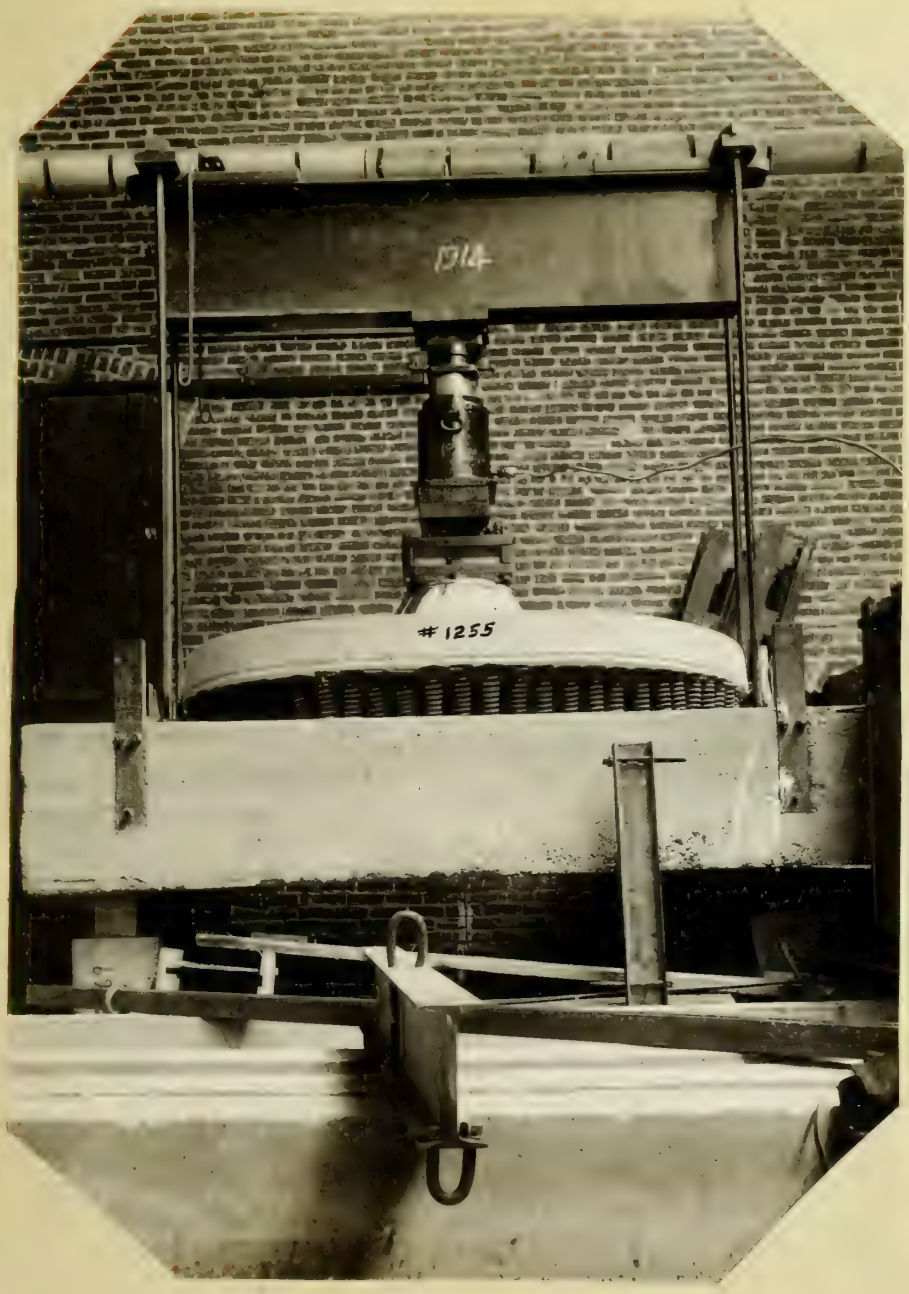


FIG. 2.

VIEW OF SLAB #1255 IN MACHINE AFTER TESTING.

II. MATERIALS, TEST SPECIMENS AND METHODS OF TESTING.

5. &6. Materials and Concrete. All the materials used were practically the same and were under the same conditions as the materials which were used in the slabs of Mr. Eells which were tested the preceding year. A description of them will be found in the corresponding articles of the thesis written by Mr. Eells. in 1913.

7. Making of Test Specimens. The slabs were built by the same men who built the slabs for Mr. Eells. They were made under much the same conditions of temperature and were of concrete from the same mixing machine. The only new material required in their making was the form for column caps of two different sizes which were used to investigate the effect of cap diameter. A description of the method of making test specimens will be found under a heading corresponding to the above in the Thesis of Mr. Eells.

8. Design of Test Specimens. The specimens were designed with the same amount of steel cutting a diametral section as was used in the slabs tested by Mr. Eells. Only two different arrangements of steel were used in the slabs. Specimens No. 1251-1254 inclusive, were made with two belts of straight rods in rectangular directions. Those rods running in a north and south direction as indicated on all the sketches were placed with a clearance of 3/4" from the bottom of the slab, and those rods running in an east and west direction were laid directly above these.

In slabs no. 1255 and 1256 the steel was composed of two rectangular belts as in the preceding specimens and in addition five welded hoops were used which were spaced equally in about the central portion of the projection beyond the cap, where the tests of Mr. Eells seemed to indicate that the maximum circumferential stresses might be expected. In slab 1257 a square mat was used which was furnished by the Barton people, and which was made similar to the mats used by them in the construction of their patent " Spider Web System" of arranging the steel around the column top. The total sectional area of steel in one belt of this mat was about the same as in all the other slabs.

Slabs no. 1255 and 1256 which contain the welded hoops, and slabs no. 1253 and 1257 containing rectangular belts and the Barton system , respectively, were all made ~~made~~ with a cap diameter of 36" inches , which was the same cap diameter as that used by Mr. Eells in all of his tests. Slabs no. 1251 and 1254 were made with cap diameters of 24 inches and 48 inches ,respectively. . In slab no. 1252 a 24inch cap diameter was used and in addition a drop of 2 inches was used. This drop was octagonal in outline and had a short diameter of 40 inches.

A comparison of slabs 1251, 1253 and 1254, should bring out to some degree the effect of cap diameter.

If there were any marked difference between slab 1251 and 1252 it should be attributed mainly to the influence of the drop.

Slabs 1253,1255 and 1256 , all have practically the same percent of steel cutting a diametral section and also have the same cap diameter, so that any difference in the strength of

1253 and 1255 or 1256, should be caused by the difference in the form and distribution of the steel. These same slabs should also bring out the effect of a concentration of steel area at some point in the section upon the distribution of the stresses in the concrete. In slabs no. 1255 and 1256 there is twice the percent of steel at that place on the diametral section where the hoops and straight rods cross together that there is at the other points in the section. In slab 1253 the steel is distributed uniformly over the whole section.

9,10 & 11. Auxiliary cubes and Cylinders, Method of Testing, and Measuring of deformations. These three headings are treated under corresponding headings in the thesis of Mr. Wells and need not here be gone into again.

DATA OF TEST SLABS Table I.

Slab No.	Cap Diam.	No. Rods in each belt.	No. of hoops.	Area of Steel cutting section	% Steel
1251	24"	23-7/16"-0		3.47 sq. in.	.625
1252	24"	23-7/16"-0		"	.625
1253	36"	23-7/16"-0		"	.625
1254	48"	23-7/16"-0		"	.625
1255	36"	20-3/8"-0	5	3.31 sq. in.	.60
1256	36"	20-3/8"-0	5	"	.60
1257	36"				

Slab 1252 has a two-inch drop, 40 inches in diameter between the cap and the slab.

All hoops are welded.

All straight rods are bent up at the ends.

The section for which the percent of steel is figured is taken in every case to be a section 5-3/4" inches in effective depth and 96 inches wide.

Figure 3.

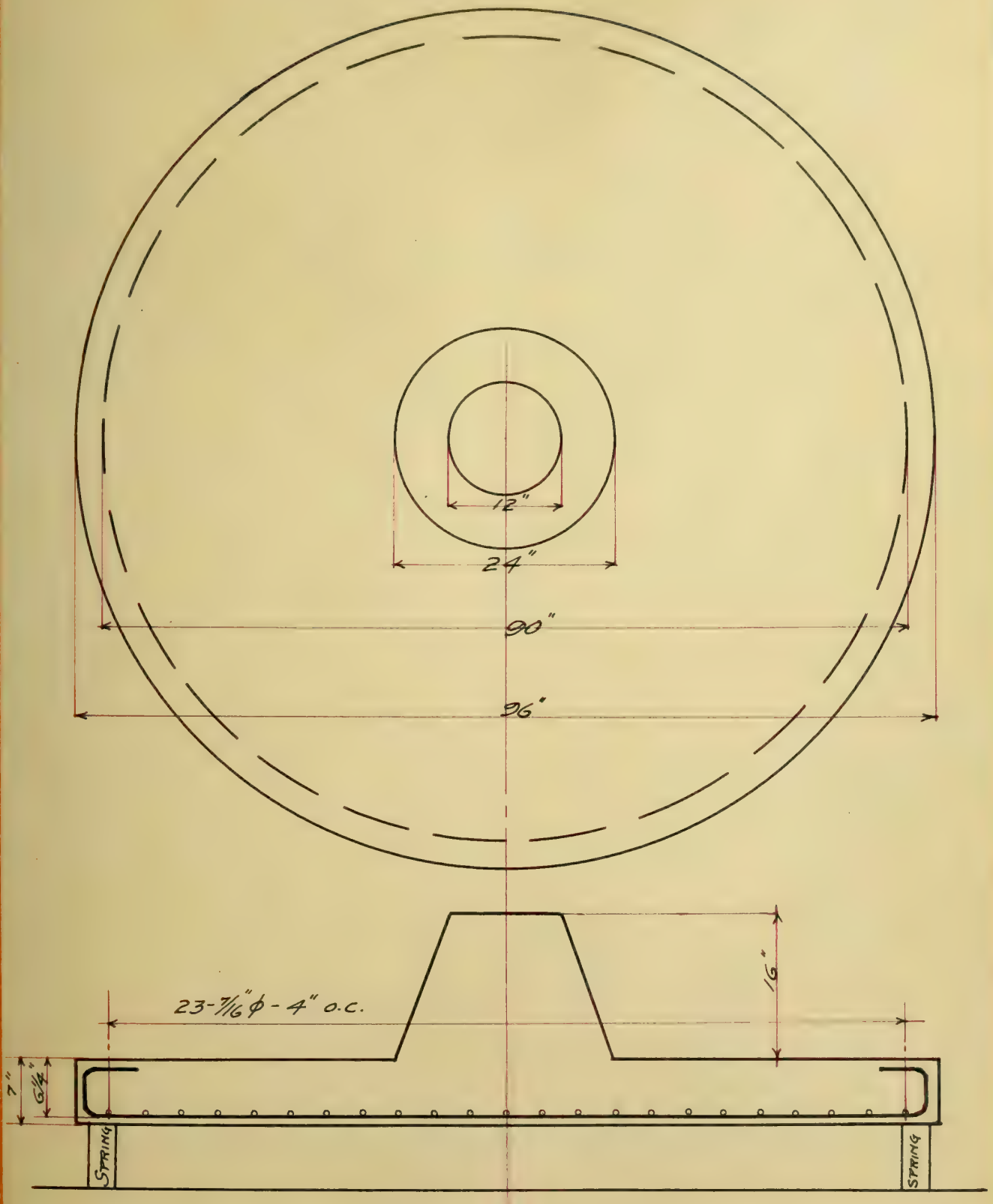
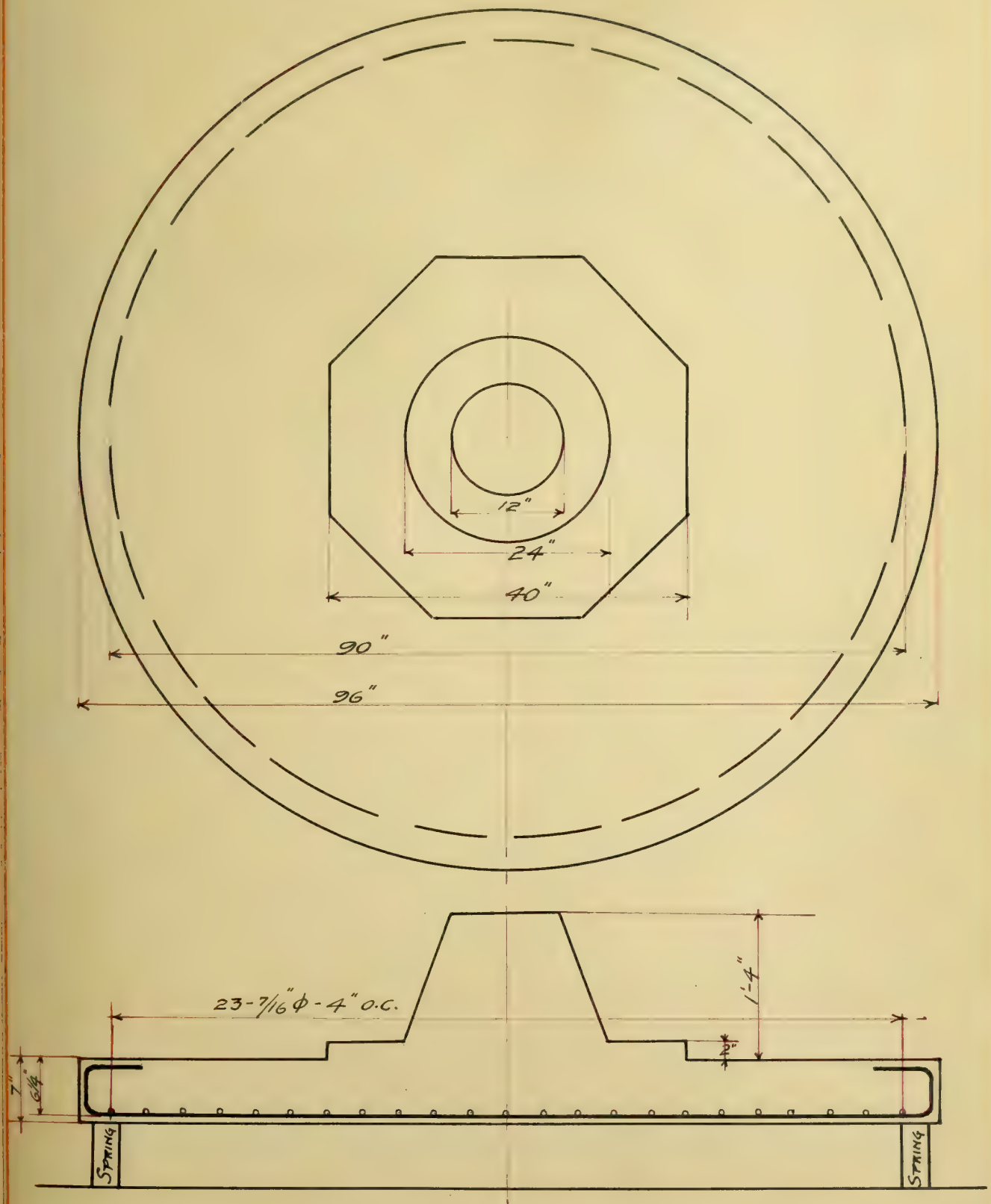


Figure 4.



SLAB # 1[illegible]

PLACING AND LOCATION OF STEEL.

Figure 5.

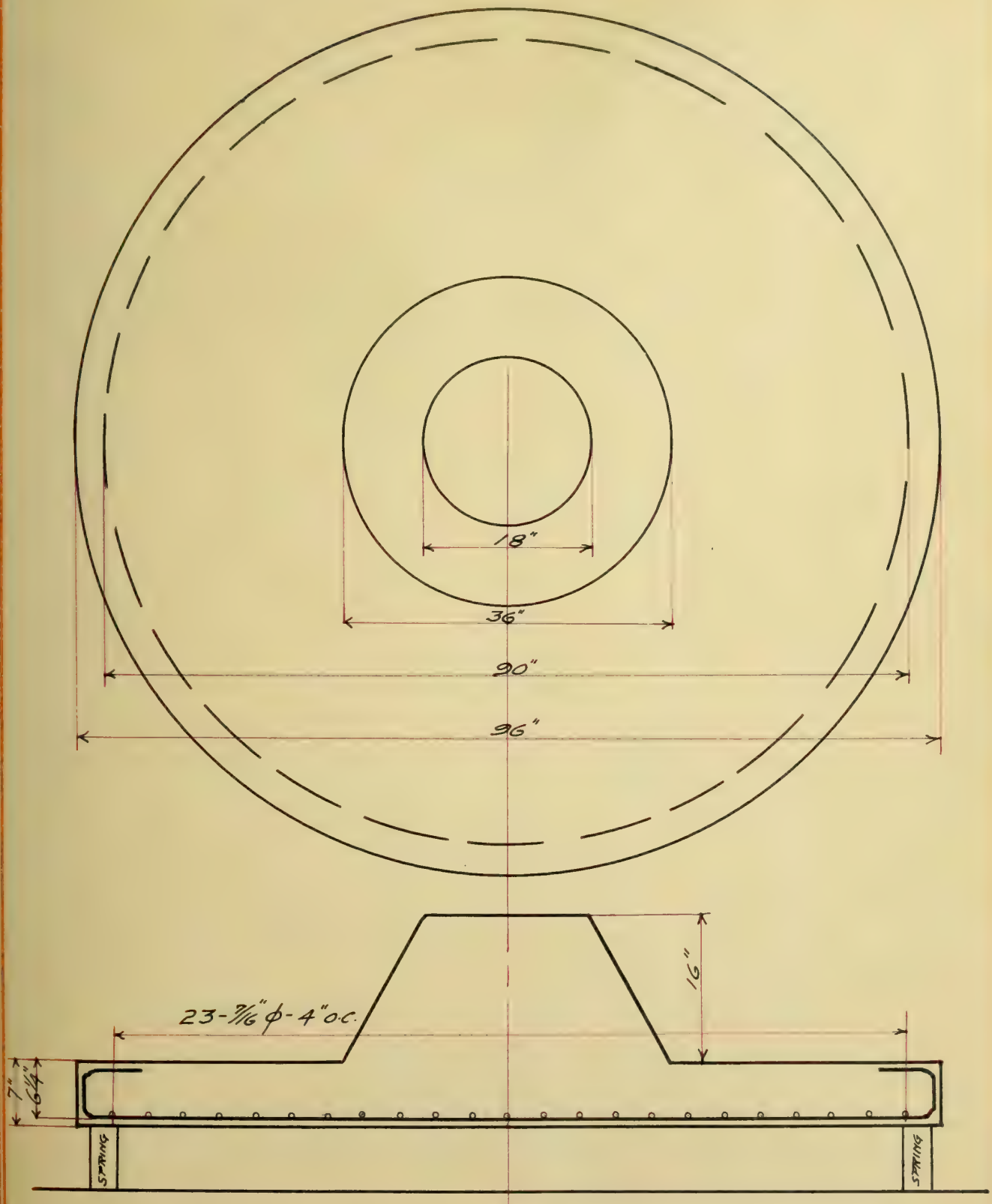
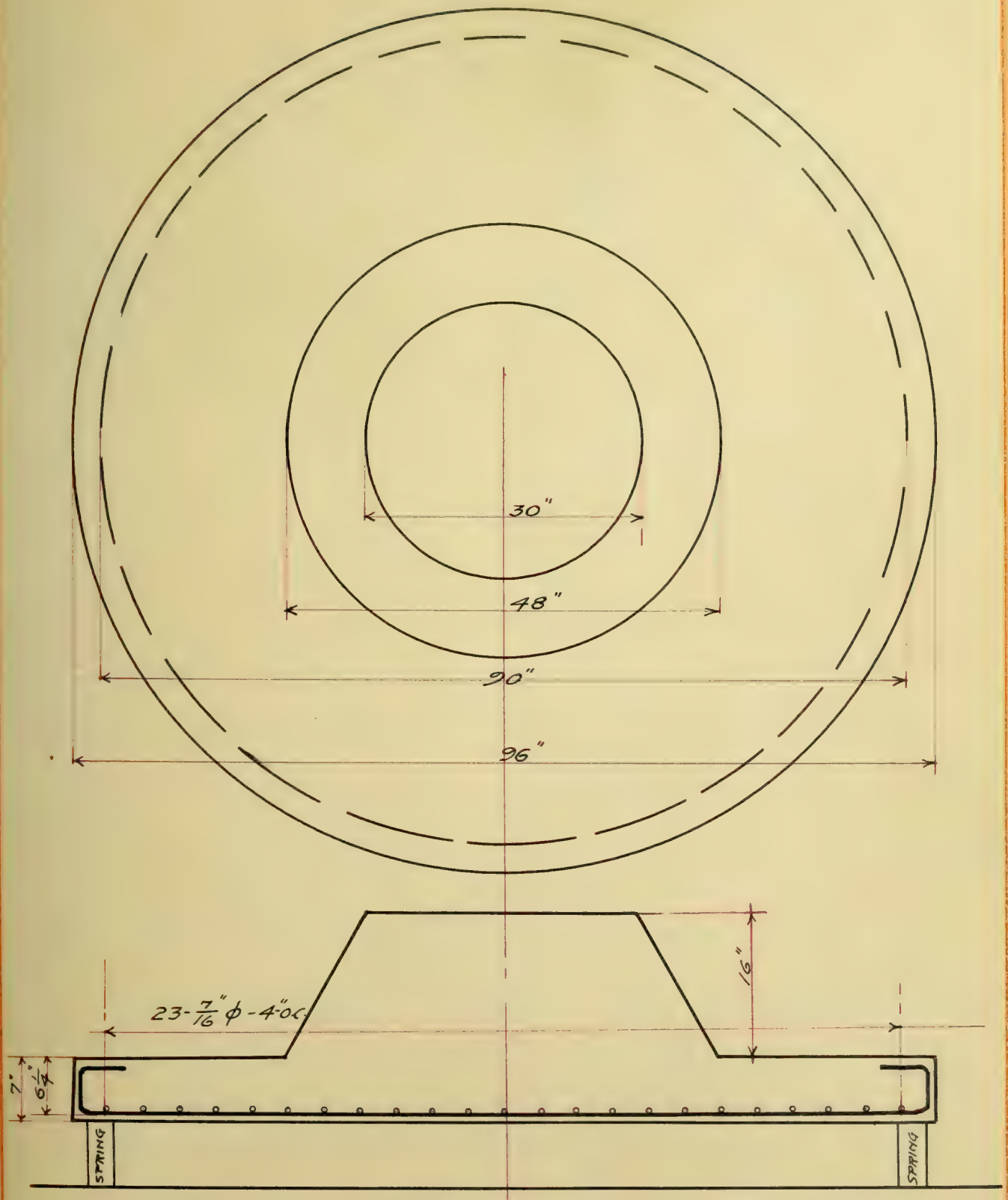


Figure 6.



CLAY / 1954

DIMENSIONS AND LOCATION OF STEEL.

Figure 7.

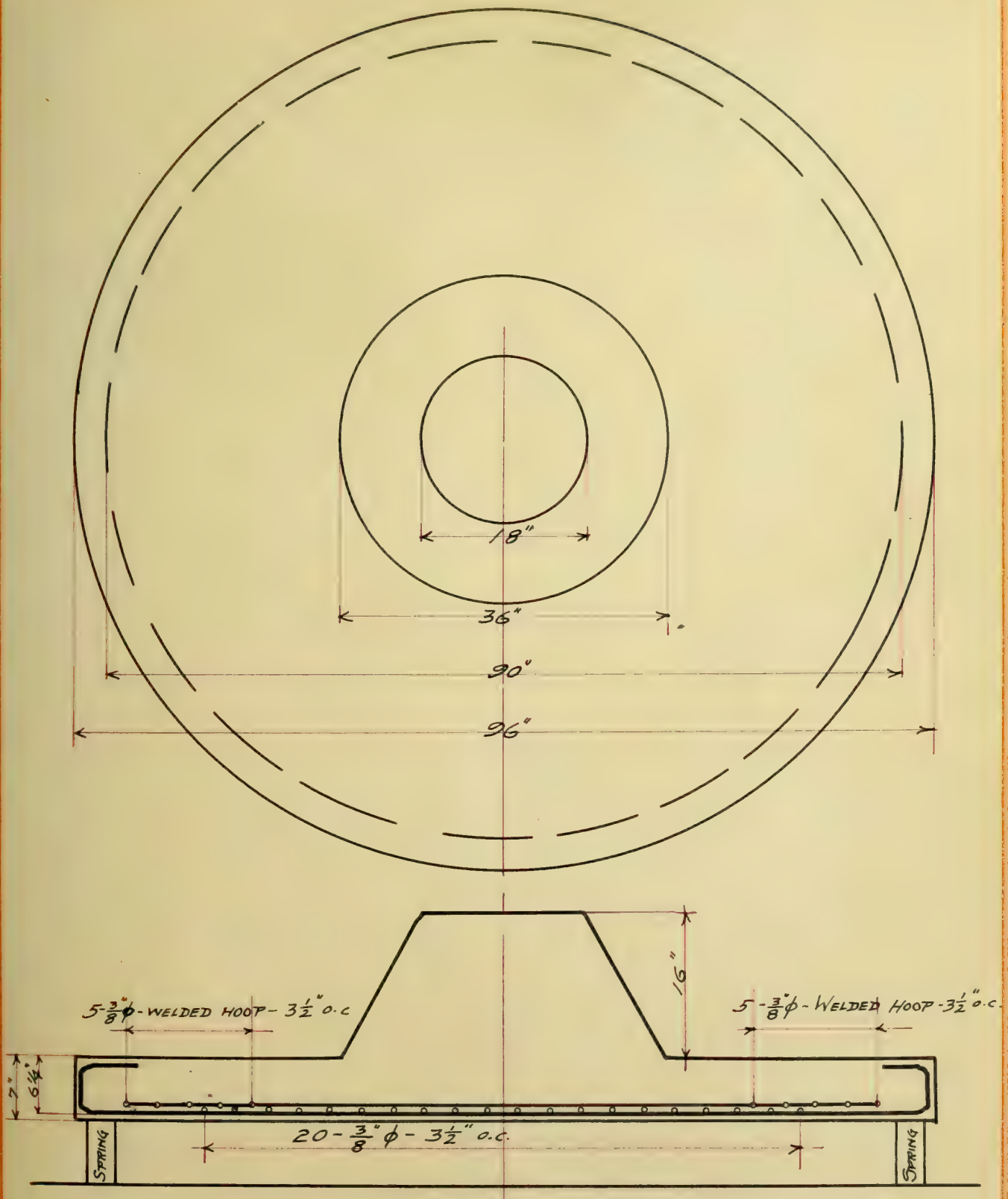
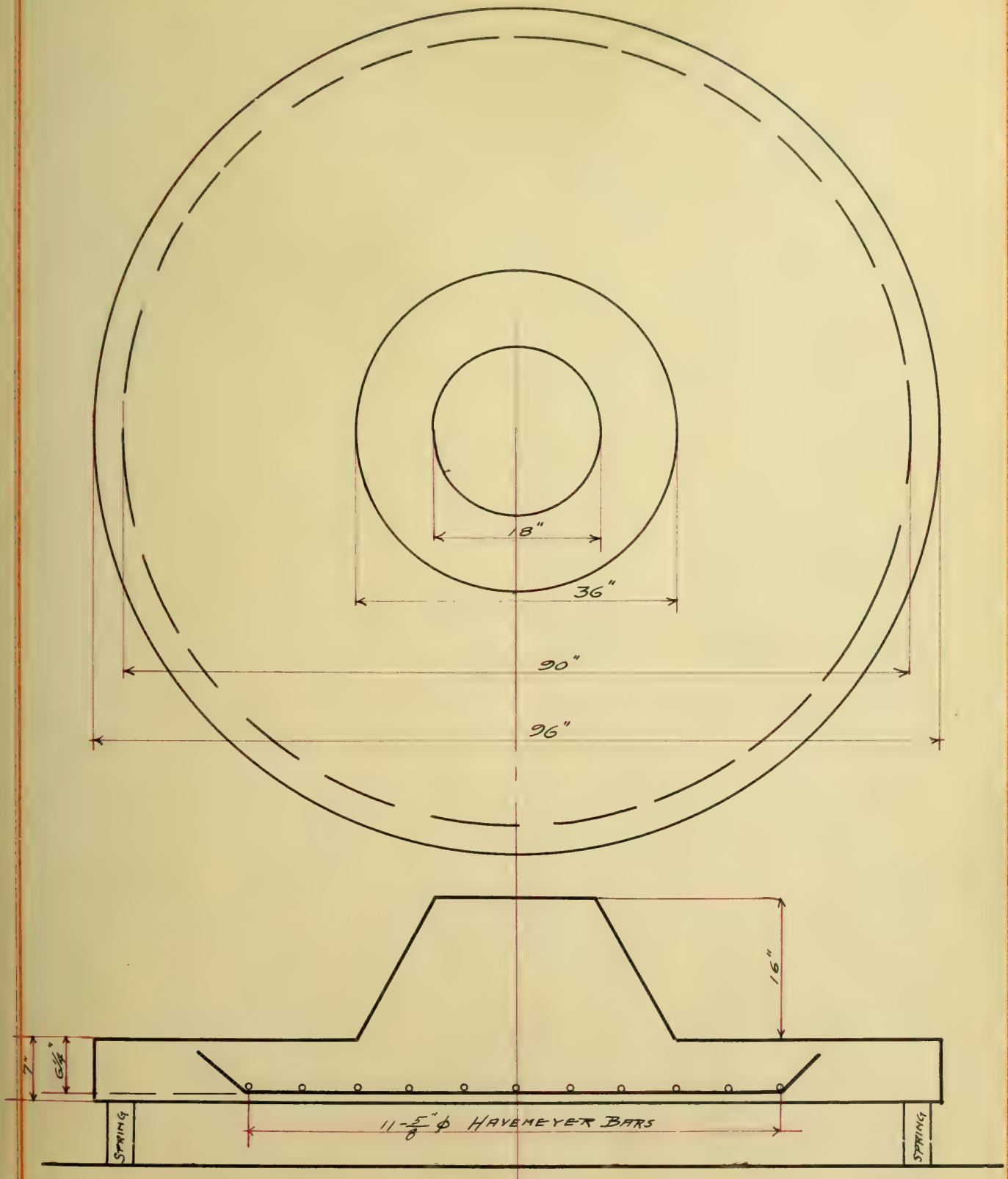

18"
36"
90"
96"
16"
5-3/8"φ - WELDED HOOP - 3 1/2" O.C
5-3/8"φ - WELDED HOOP - 3 1/2" O.C.
7"
5 1/2"
20 - 3/8" φ - 3 1/2" O.C.
SPRING
SPRING

Figure 8.



18. Cube and Cylinder Test Data

Auxiliary Specimens .- Three cubes and one cylinder were made from the concrete out of the batches for the specimens. For every specimen except 1252 this was done and the auxiliary specimens thus obtained were stored in damp sand and tested about the time the test specimens were tested. The accompanying table gives the results of these tests. The cubes were made eight inches on a side and the cylinders were made sixteen inches long and eight inches in diameter.

COMPRESSION TESTS OF CUBES AND CYLINDERS.

Table II.

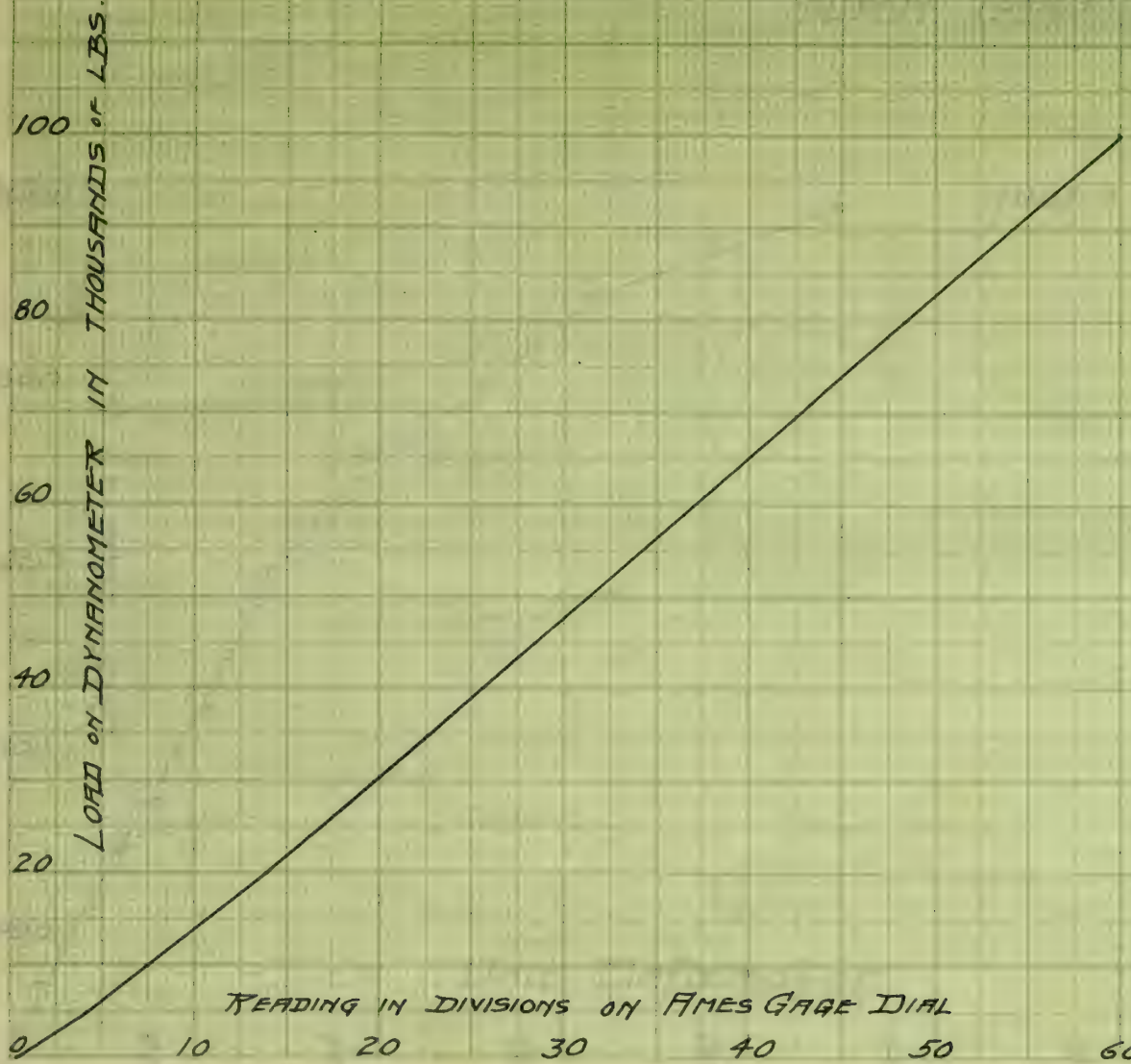
Maximum Loads given in Pounds per sq. inch.

Slab No.	Cubes		Cylinders	
	Age Days.	Max. Load.	Age Days	Max. Load
1251	60	2350	60	2080
1252				
1253	69	2480	69	2040
1254	61	2770	61	
1255	63	2550	63	2570
1256	53	2300	53	2300
1257	70	2610	70	2400

There are no cubes and cylinders for 1252.

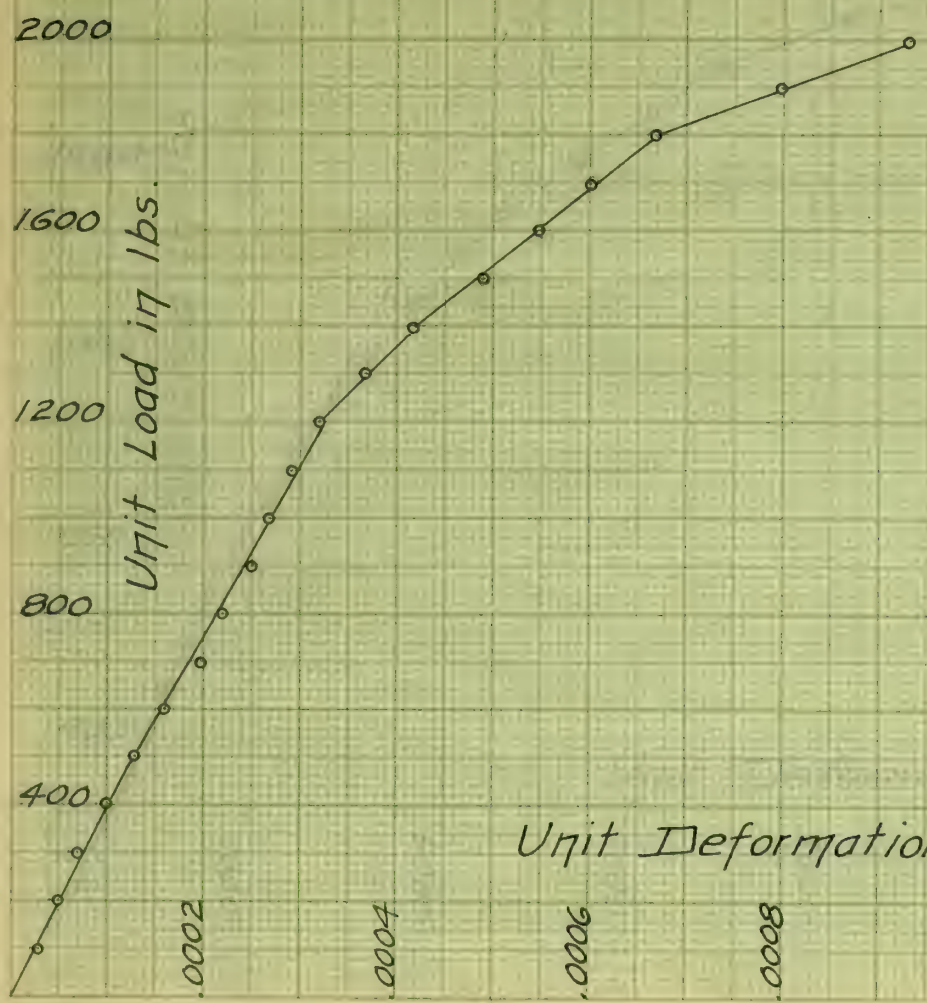
The cylinder for 1254 was not tested to its maximum.

Calibration Curve of Dynamometer



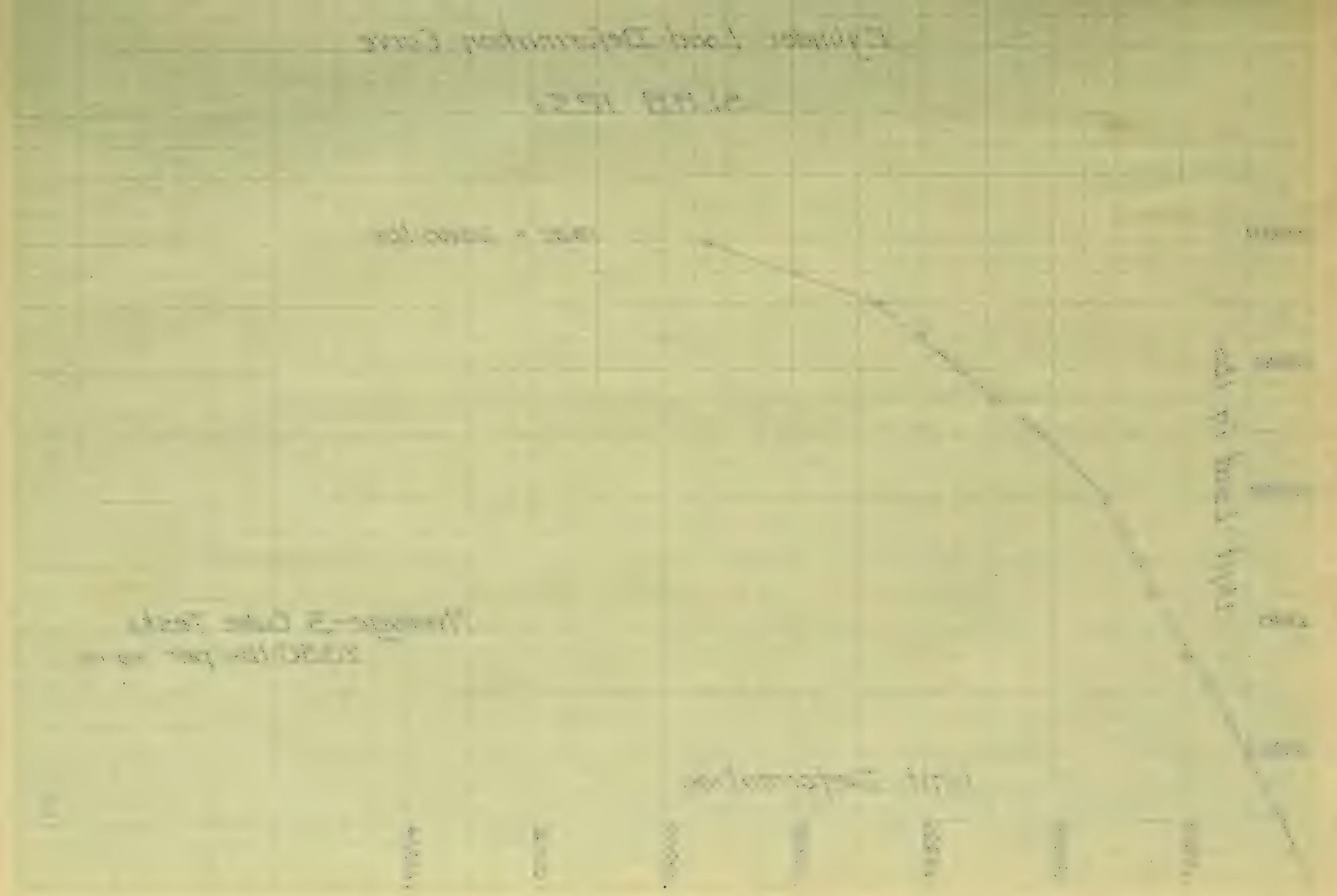
Cylinder Load-Deformation Curve

SLAB 1251



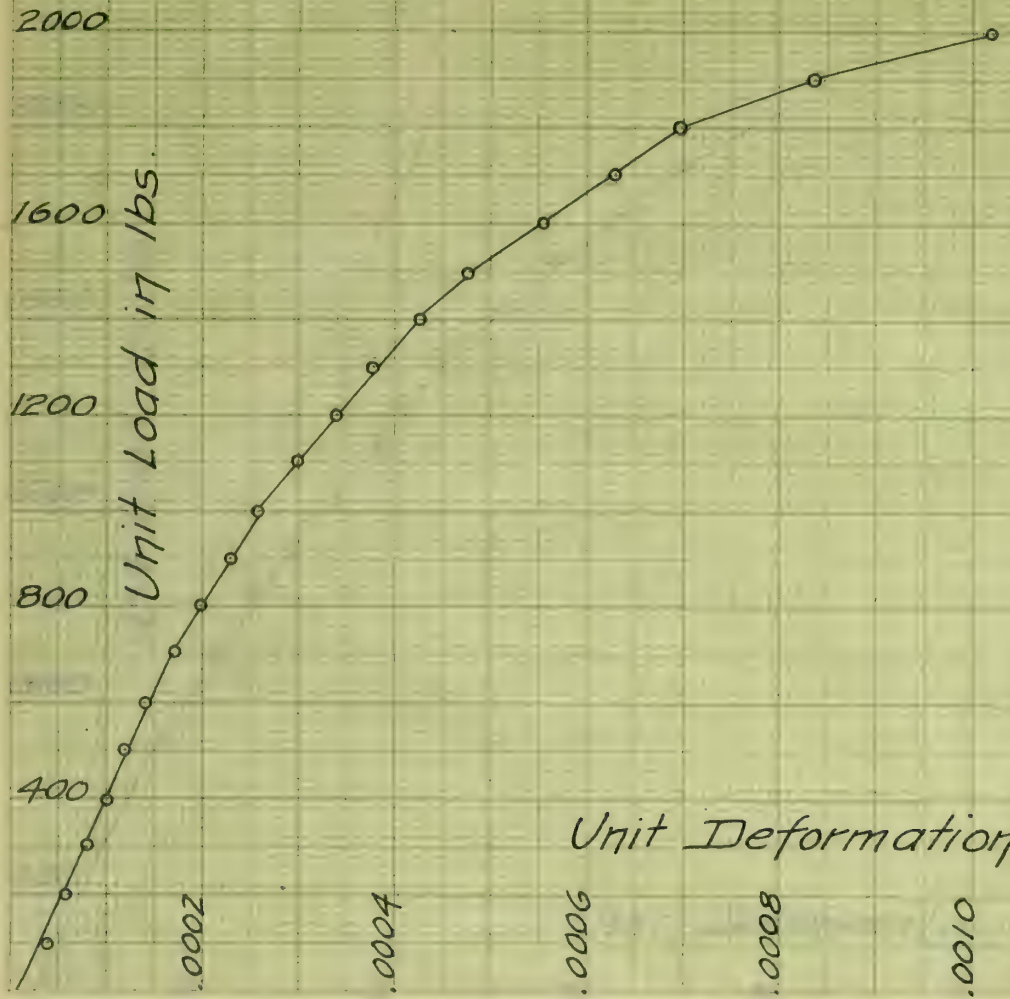
max = 2080 lbs.

Average-3 Cube Tests
2350 lbs. per sq. in.

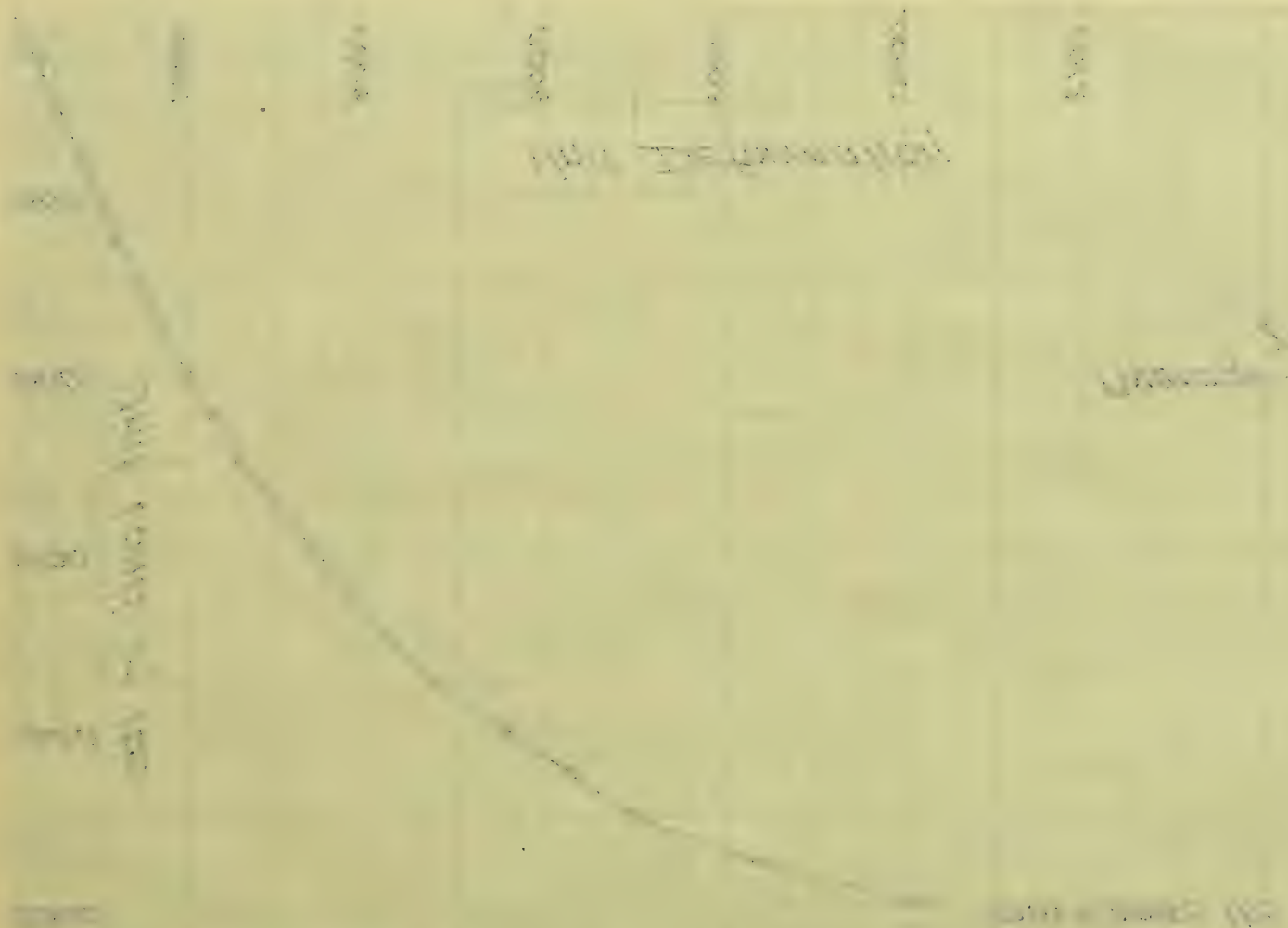


Cylinder Load-Deformation Curve

SLAB 1253

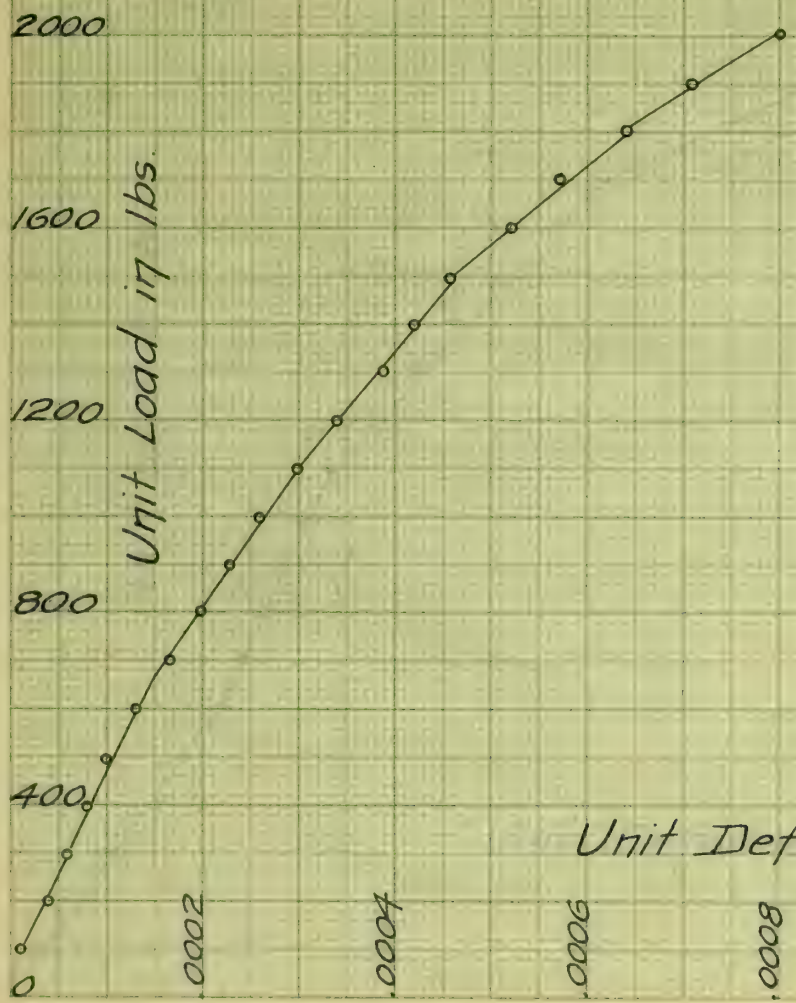


Average - 3 Cubes Tested
2480 lbs. per sq. in.

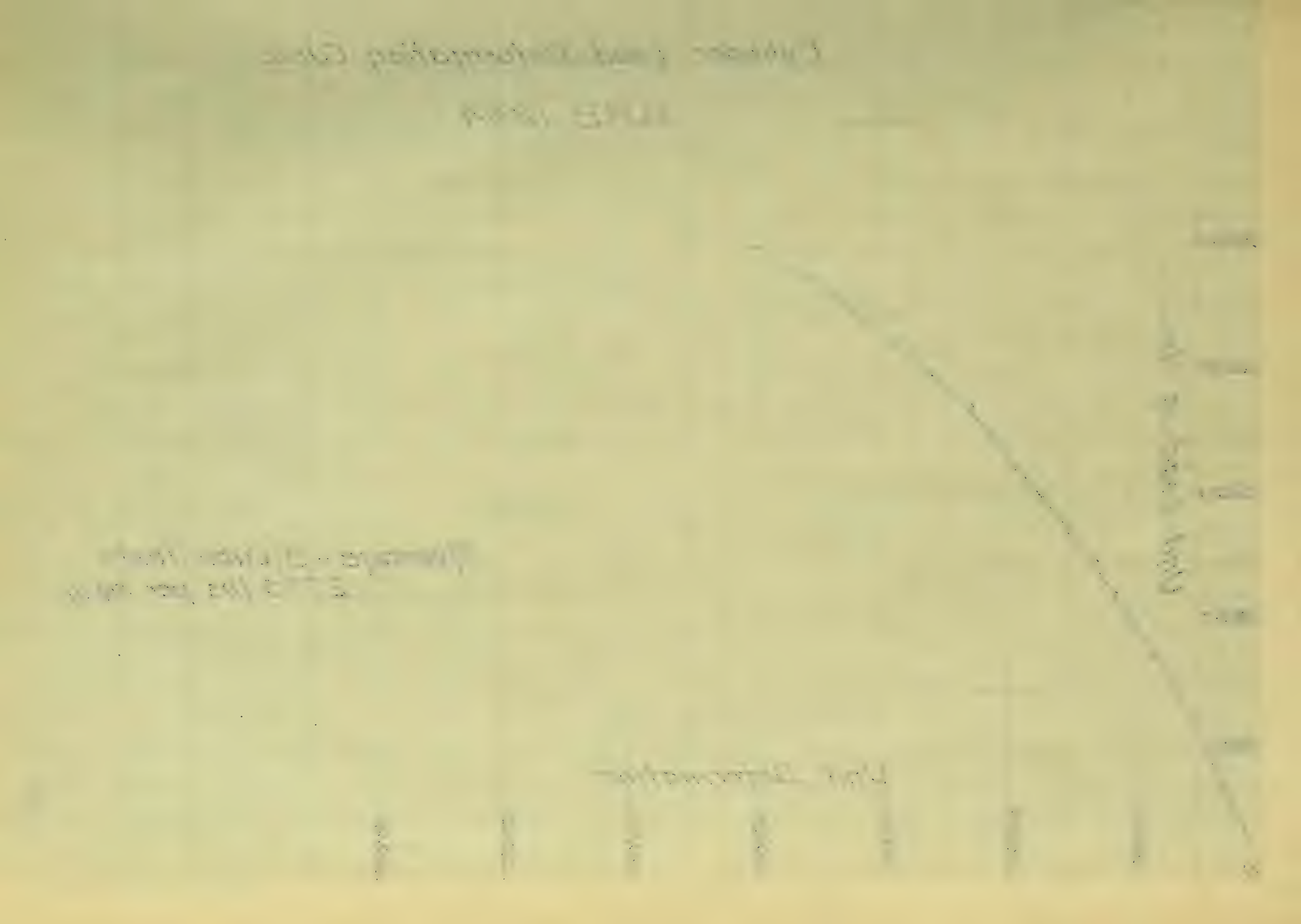


Cylinder Load-Deformation Curve.

SLAB 1254

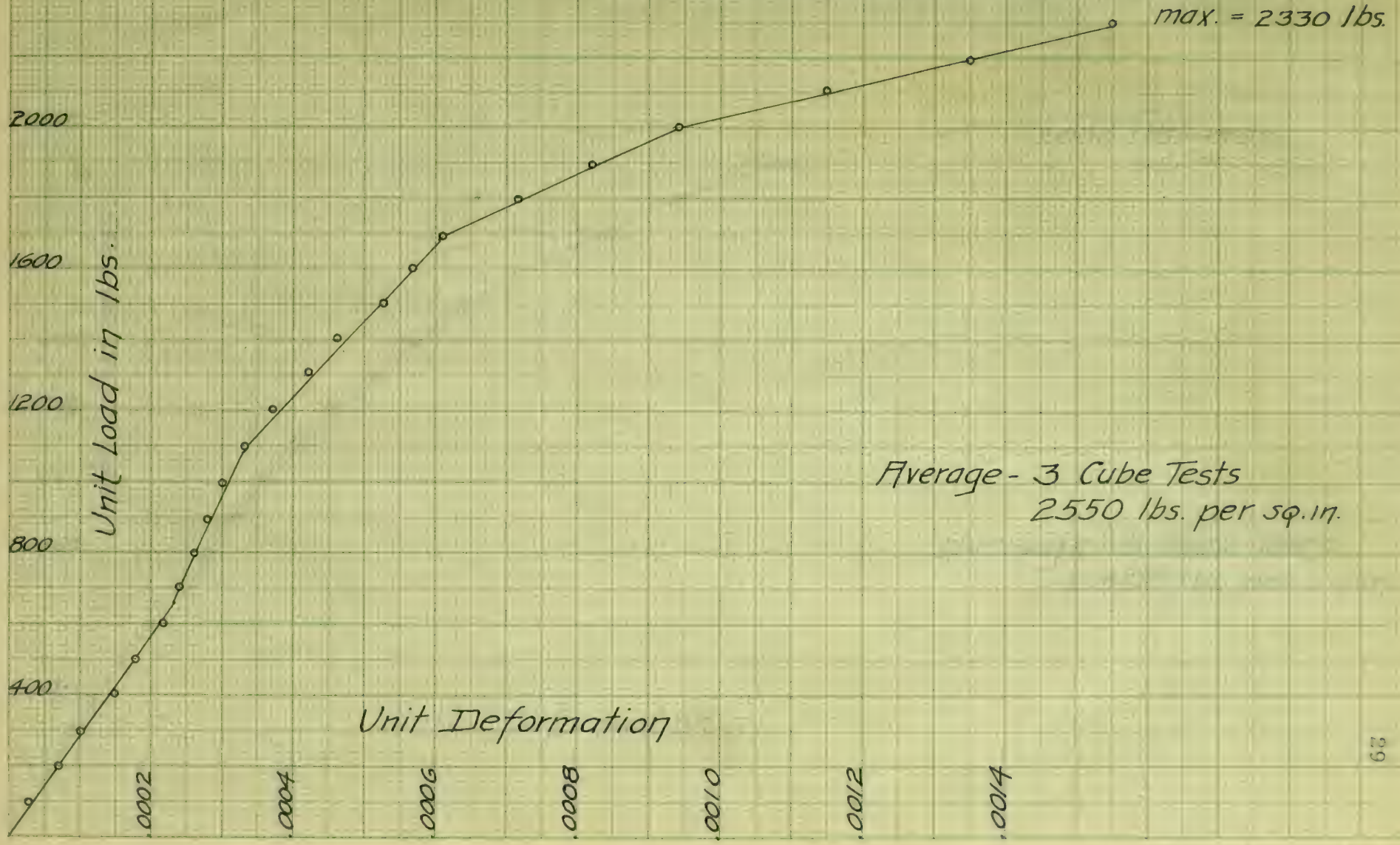


Average - 3 Cube Tests
2770 lbs. per sq. in.



Cylinder Load-Deformation Curve

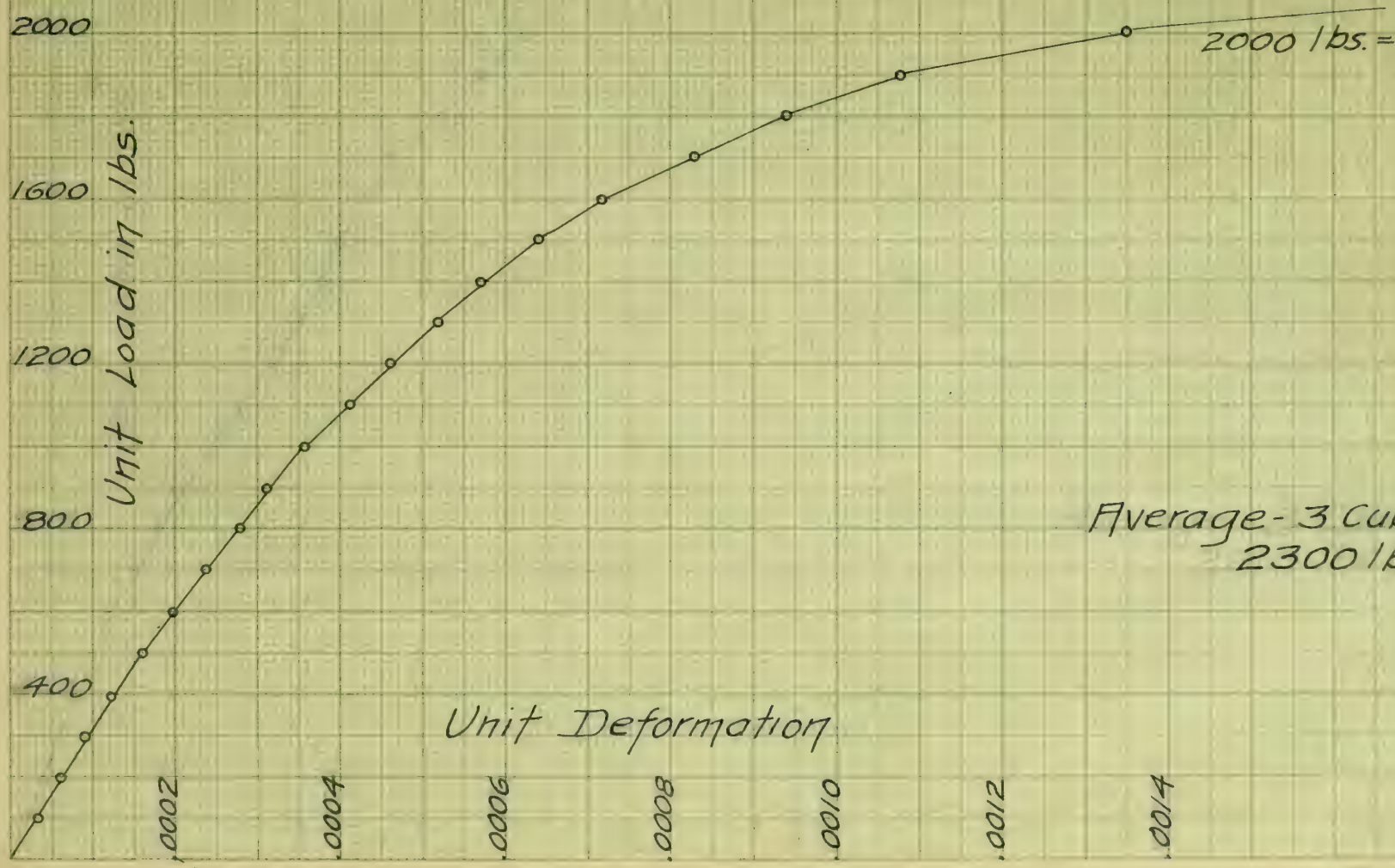
SLAB 1255



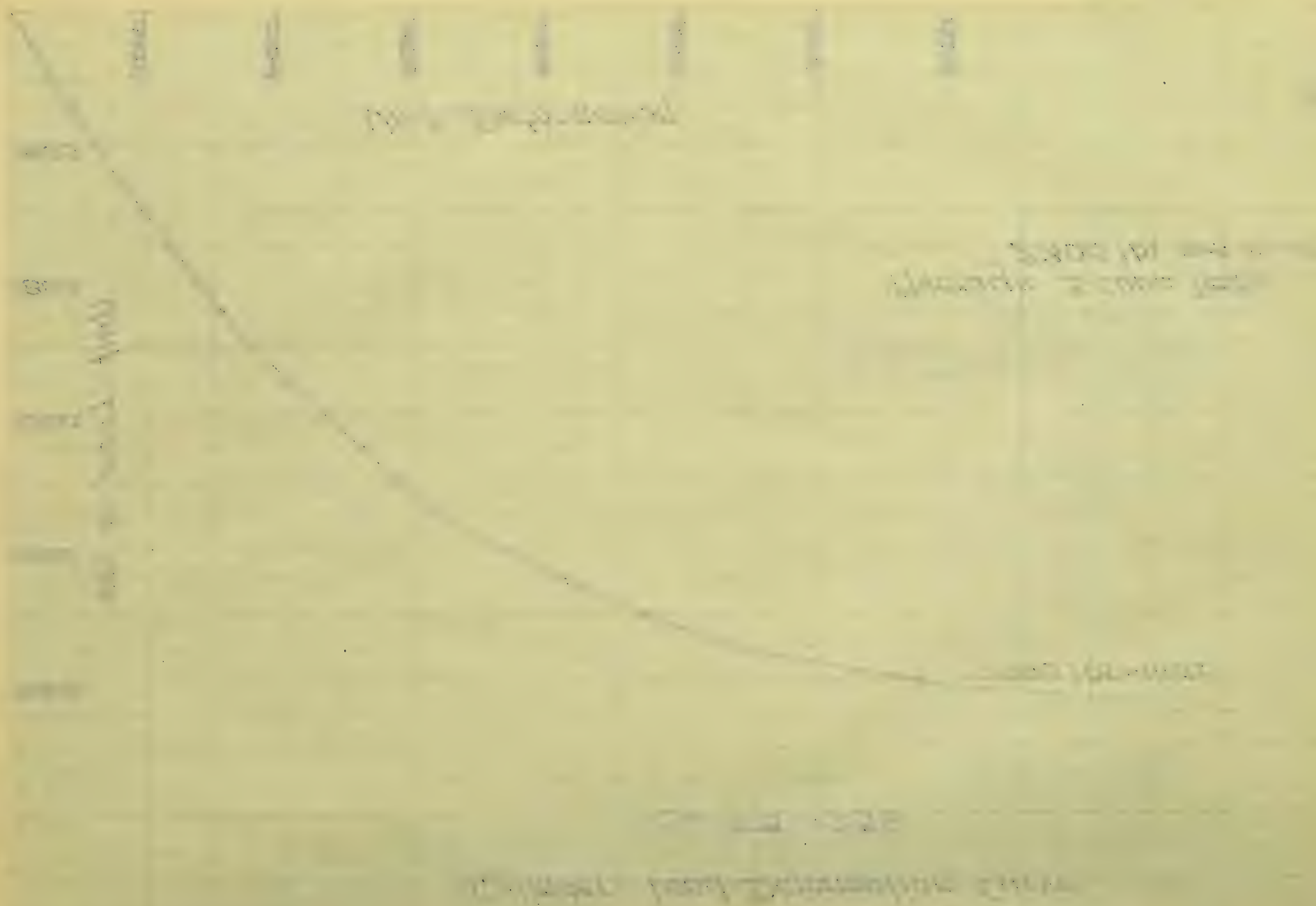
Average - 3 Cube Tests
2550 lbs. per sq. in.

Cylinder Load-Deformation Curve

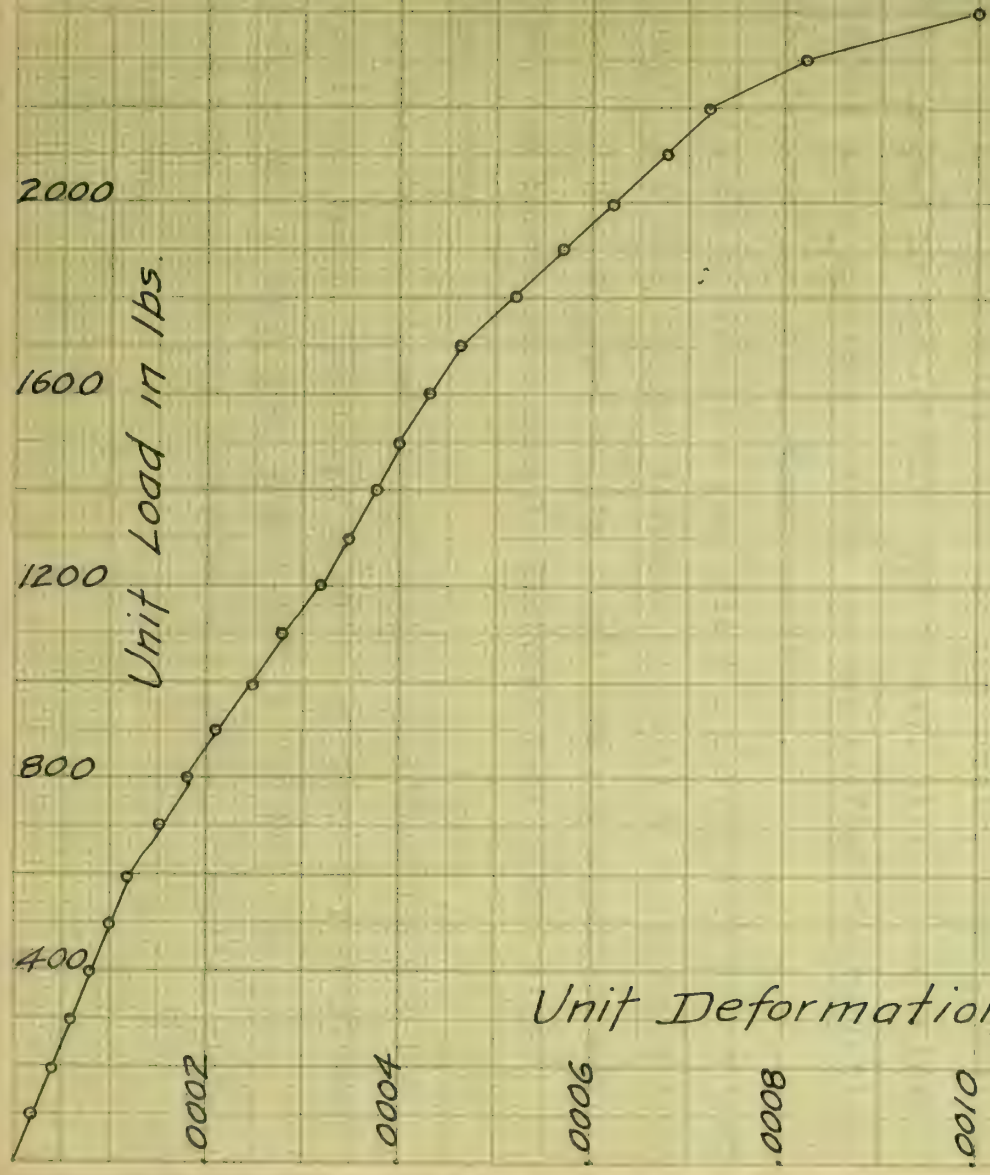
SLAB 1256



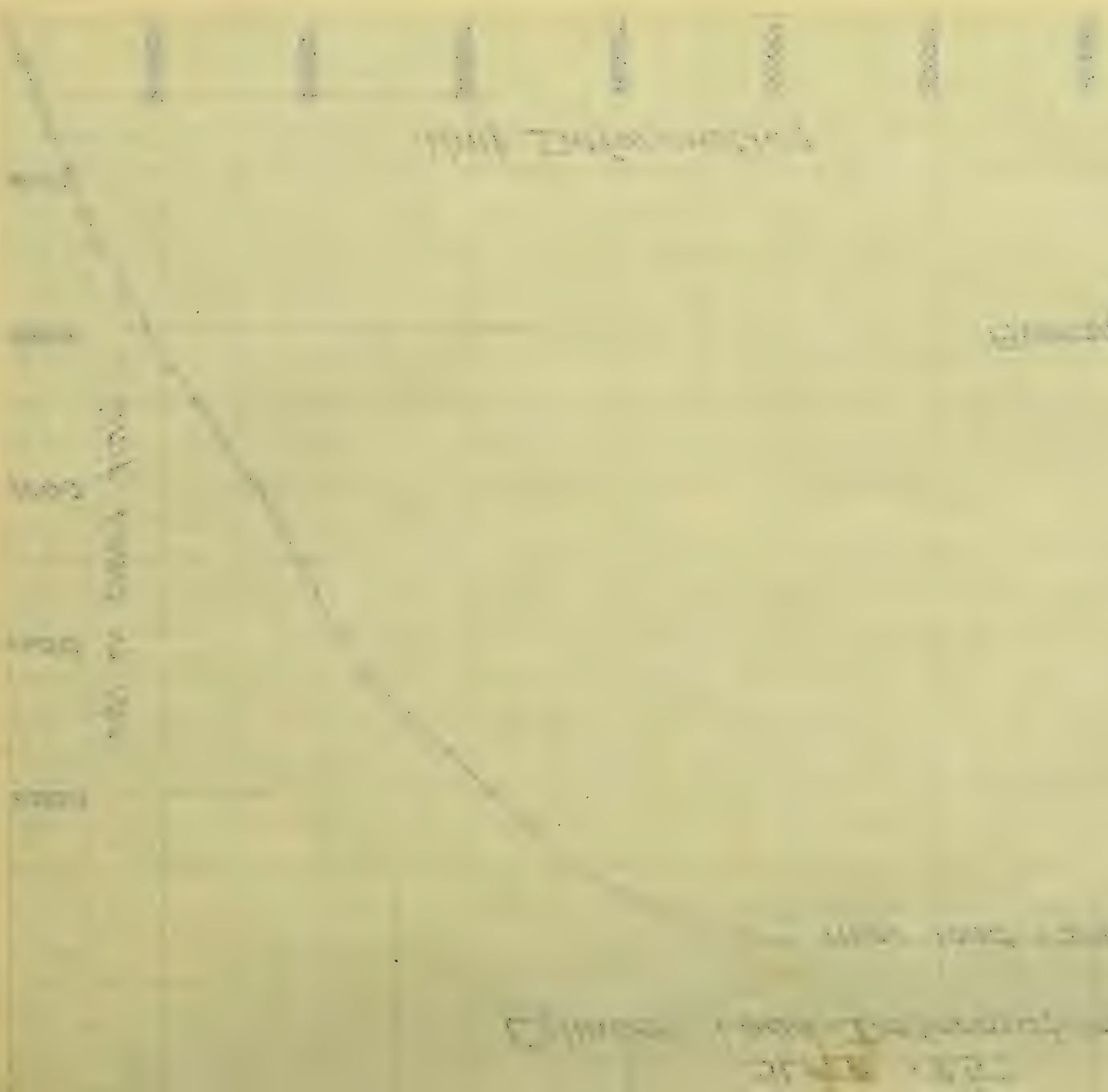
Average - 3 Cube Tests
2300 lbs. per sq. in.



SLAB 1257
Cylinder Load-Deformation Curve



Average - 3 Cube Tests
2610 lbs. per sq. in.



11. Slab Data. All the experimental data from the slab tests were obtained from readings on the various gage-lengths with the Berry Extensometer. The majority of the gage lines were located along the two perpendicular diameters which run parallel with the rods in the two rectangular belts which were used in every slab tested. Those gage-lines which run in a radial direction are designated on all the curves and sketches by the first letters of the alphabet. Those gage-lines which are perpendicular to these diameters or which are circumferential are designated by numbers. Other gage-lines were located around the cap and were put there for the purpose of finding the stresses across that part of the section assumed for calculating the equilibrium between bending and resisting moments, which is along the arc of a circle concentric with the cap circle. These gage-lines are designated by the letters, M, N O and P. Still other points are taken along sections outside the cap to find the variation of the deformations along these sections.

With all of the data possible the curves were determined by plotting stress against distance measured along certain lines. For some of the isolated points which were not a part of any series, the curves were made by plotting load on the slab against stress.

Only two different gage-lengths were used for all the observations taken. The large majority of these were six-inch gage-lengths. On each slab except 1257 a few two inch gage-lengths were read on the concrete in a radial direction close up to the cap.

One division on the Ames dial attached to the extensometers indicated a stress of 1200 pounds per sq. inch in the steel and of 1200/n pounds per sq. inch in the concrete. "n" is here used to indicate the ratio of the moduli of the steel and the concrete.

All the curves were therefore conveniently plotted by using directly as stress , the corrected differences from the data sheets.

All the individual curves were plotted first and they were then averaged, first along a whole diameter and then along a radius .

In all the curves for the final average circumferential stress along a radius the stress perpendicular to two different sections is included. Both of thesesections have the distance from the outside of slab to the edge of the cap in common. Then one of these sections follows the radius straight on to the center of the slab and the other follows the arc of a circle around the outside of the edge of the cap. Stresses on the section which follows the radius right through to the center could, of course, not be obtained for the concrete between the edge of the cap and the center of the specimen.

MAXIMUM LOAD CARRIED BY SLABS Table III.

Slab No.	Made	Tested	Age Days.	Max. Load In Lbs.
1251	12-19-13	3-18-14	61	73000
1252	1-15-14	3-16-14	60	76000
1253	12-10-13	2-11-14	63	83000
1254	1-7-14	3- 7-14	59	100000
1255	1-23-14	3-21-14	57	86000
1256	2- 2-14	4- 3-14	60	91500
1257	2-27-14	5- 5-14	67	70000

Slab 1254 did not reach its ultimate strength at 100000 pounds but was not loaded any higher.

An examination of the loads carried by the different test specimens indicates that the size of cap has a very marked influence on the maximum load carried by the slabs, even though the percent of steel is the same in them all.

Slab 1257 is an exception to this rule but should not be considered since it failed in an entirely different manner from the remaining slabs.

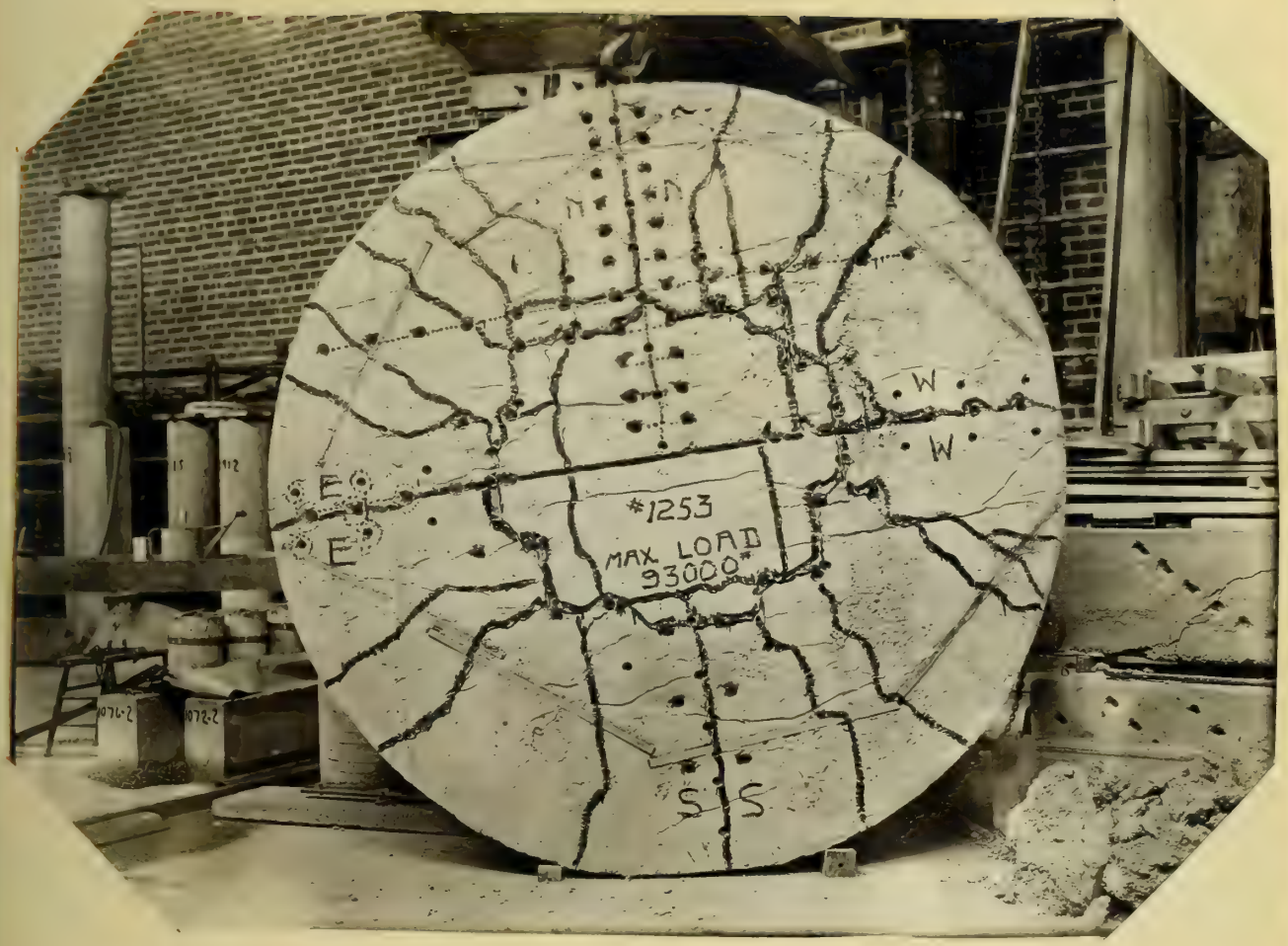


Figure 9.

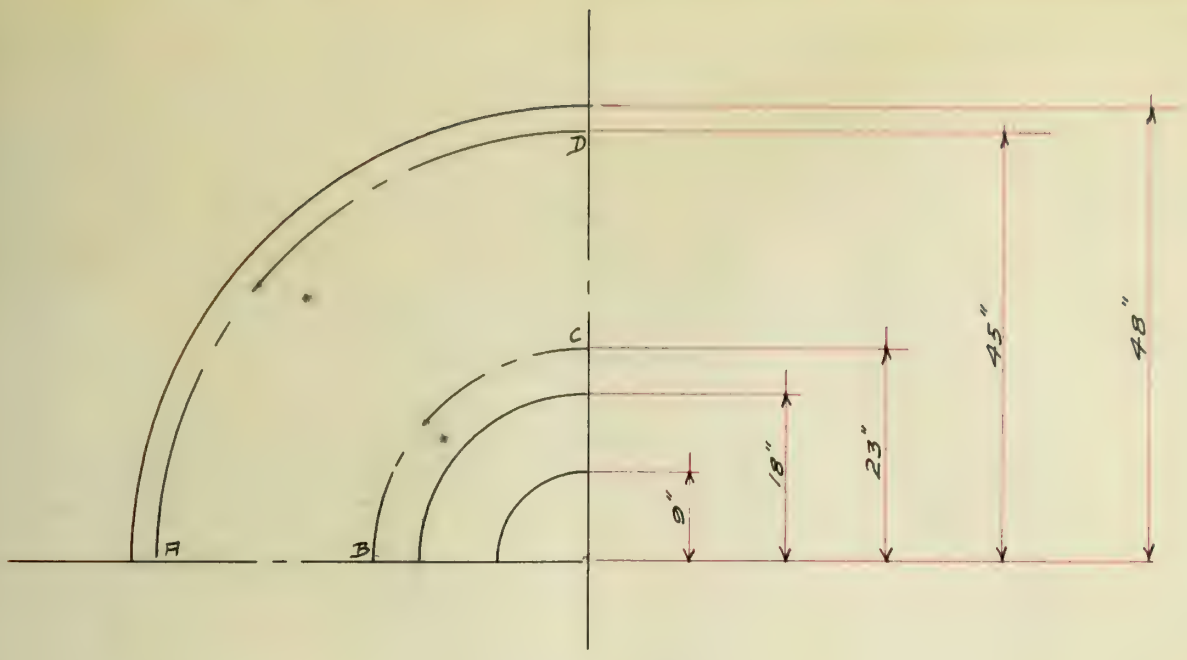
VIEW OF SLAB # 1253 AFTER TESTING.

A. Slab with rectangular Reinforcement and 36 inch cap.

14. Theorems of tests . The method of failure of slab 1253 which was the only one with rectangular reinforcement and 36 inch cap, was by tension in the steel primarily. Fine hair cracks appeared at the lowest load and at a load of 45000 lbs. the cracks became wide enough to be very noticeable. The ultimate failure which occurred at a load of 53000 lbs. was a sudden one and was caused by the punching through of the cap. It is quite probable that the opening up of the tension cracks to a considerable height on the section around the cap weakened this section in such a manner as to make this method of failure possible.

The rods which passed over the cap did not fail in bond as the rapid reduction of the stress in all the rods to zero at the center shows

15. Load Deformation Relations. The curves shown in the following pages show the variation of deformation with load on all of gage-lines at which readings were taken. In this and in all of following tests discussed, a section of the slab is assumed on which all of the stresses are known in a direction which is perpendicular to the part of this assumed section which lies along a diameter. As shown in the following sketch accompanying the computations for equilibrium of bending moment and resisting moment on this section, a part of this section lies along a diameter and the remainder of it is along an arc of a circle which is concentric with the cap circle and which cuts several gage lines radially labeled in the following curves as I, I I, I I I,



Slab 1253.

Equilibrium Calculations.

The bending moment equals .707($\frac{45-23}{4}$)60000 or 234000 inch pounds, in the direction CD on the section ABC.(N=60000#)

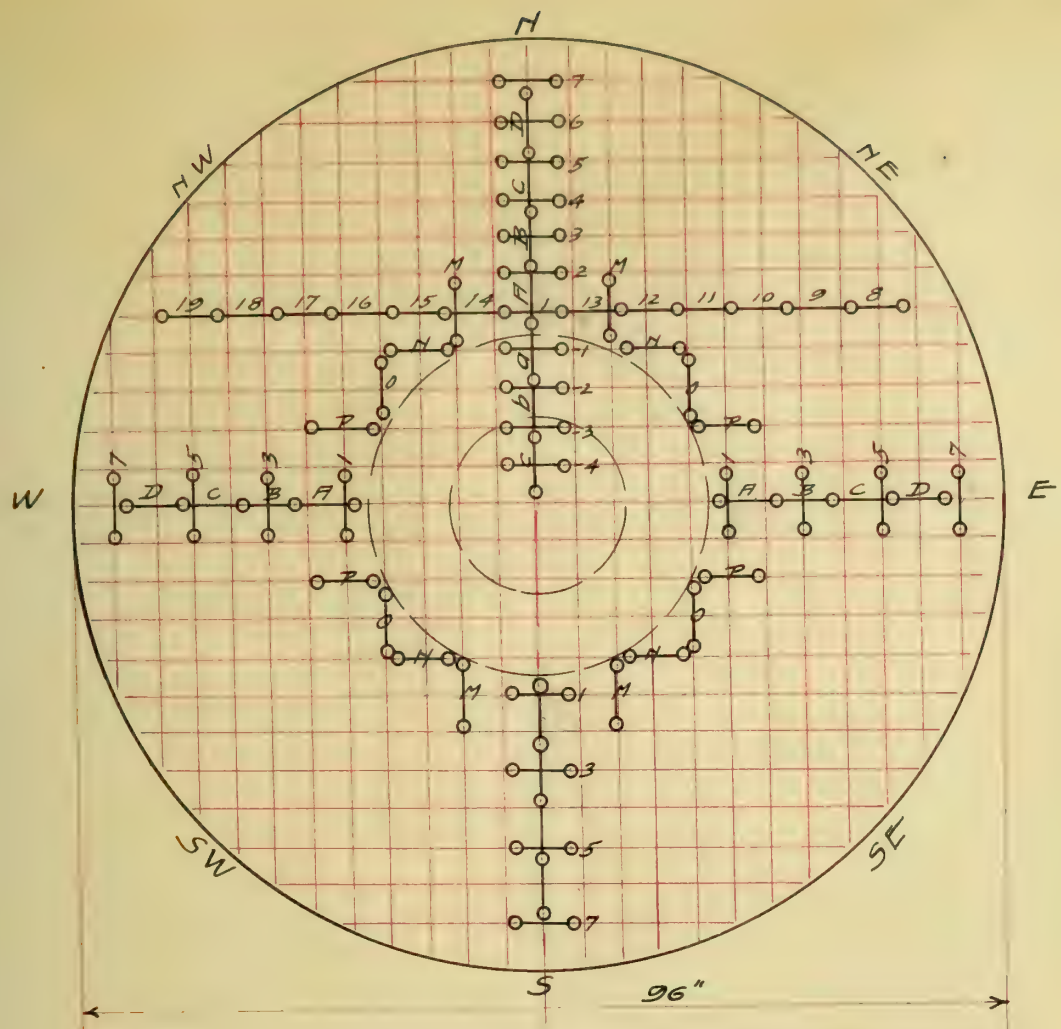
11 1/2 - 7/16 inch. diam. rods cut the section.

A_s equals 1.73 sq. inches.

The average steel stress for a load of 60000 pounds equals 30000 pounds per sq. inch on all the rods cutting the section ABC in the direction CD.

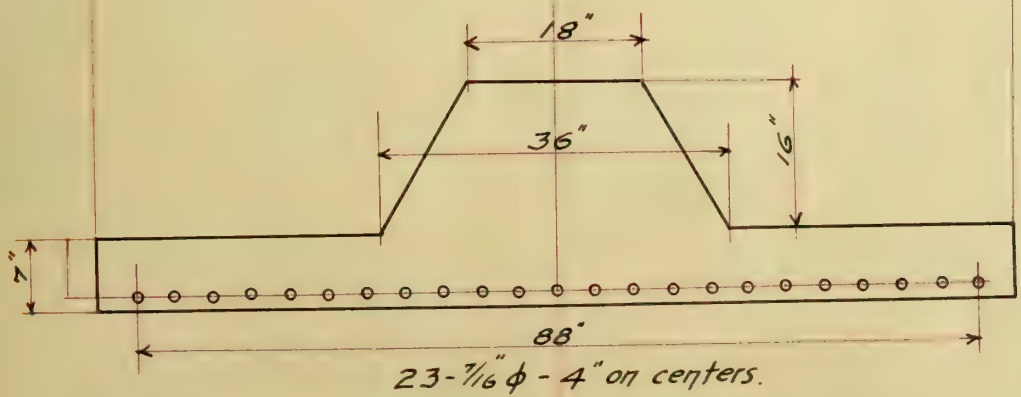
Therefore the effective depth or jD becomes

234000/1.73(30000) or 4.5 inches



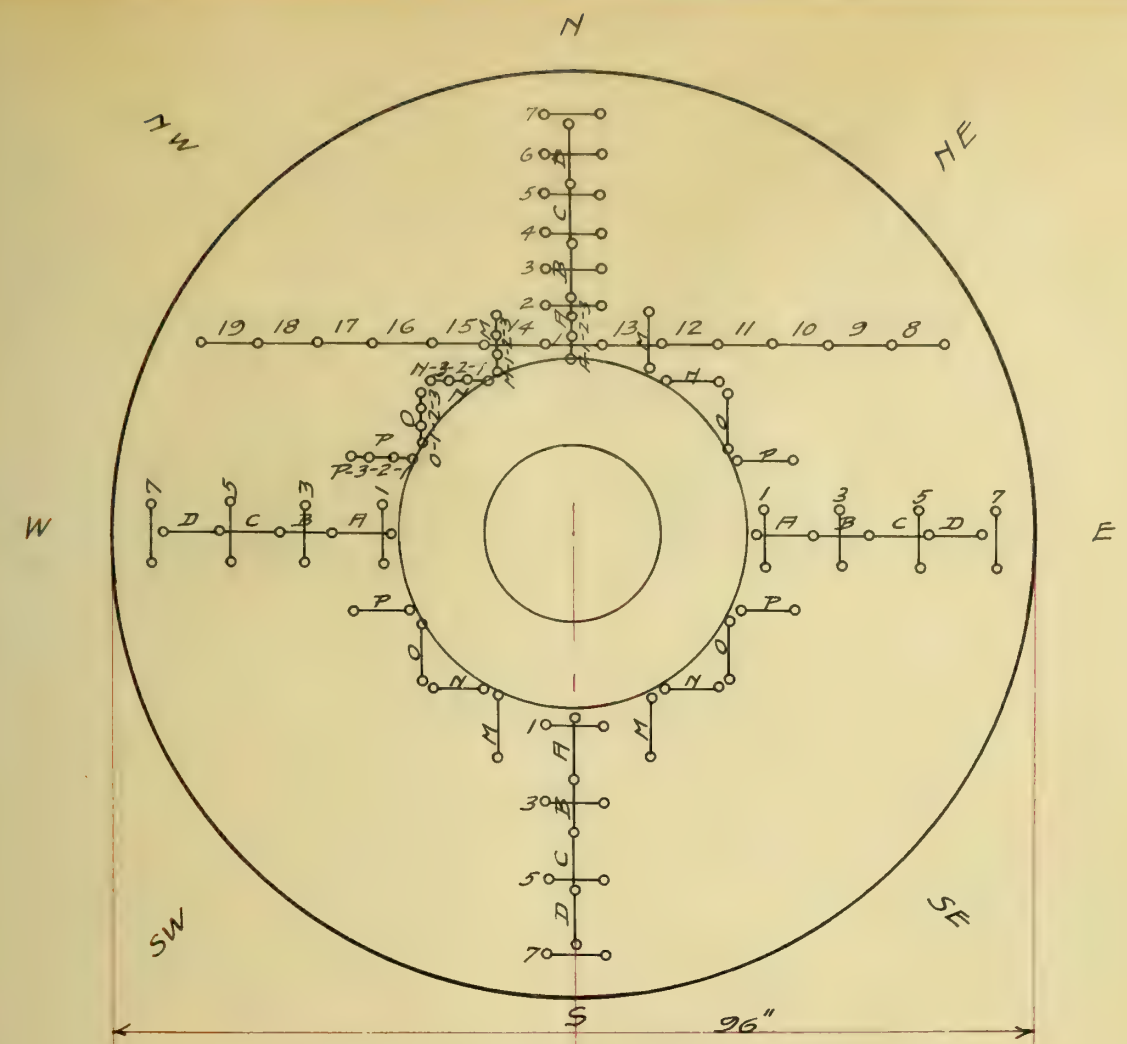
GAGE LINES IN STEEL
SLAB 1253

Figure -- 10



23-7/16" ϕ - 4" on centers.

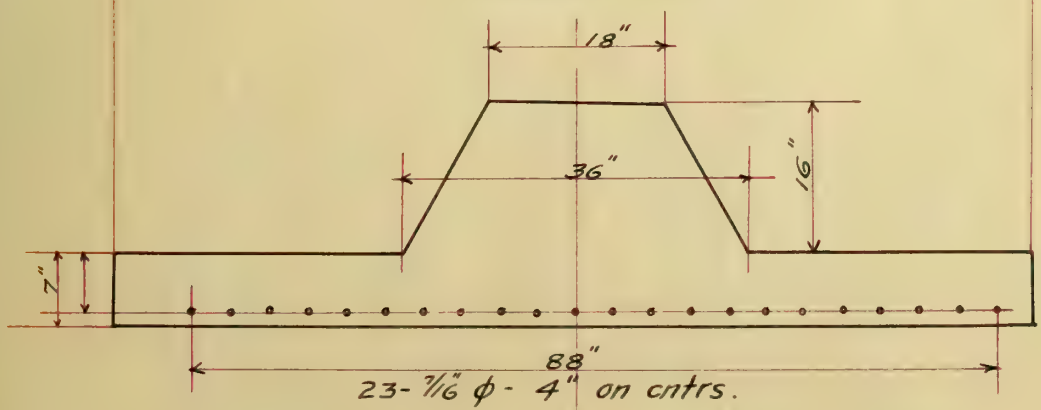
p = .625%



Gage Lines in Concrete

SLAB-1253

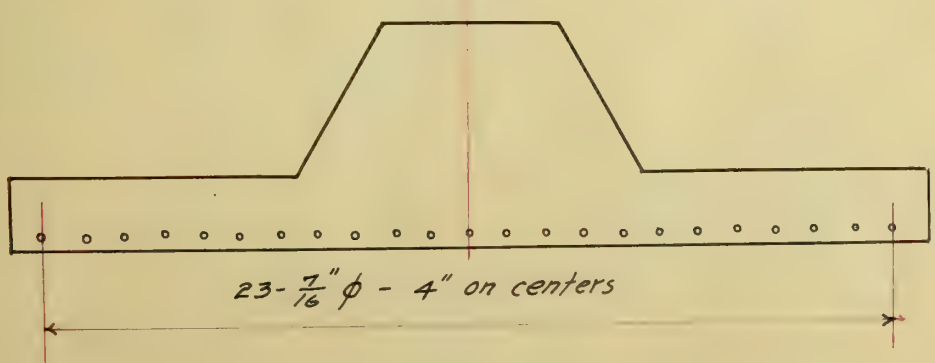
Figure ---11.



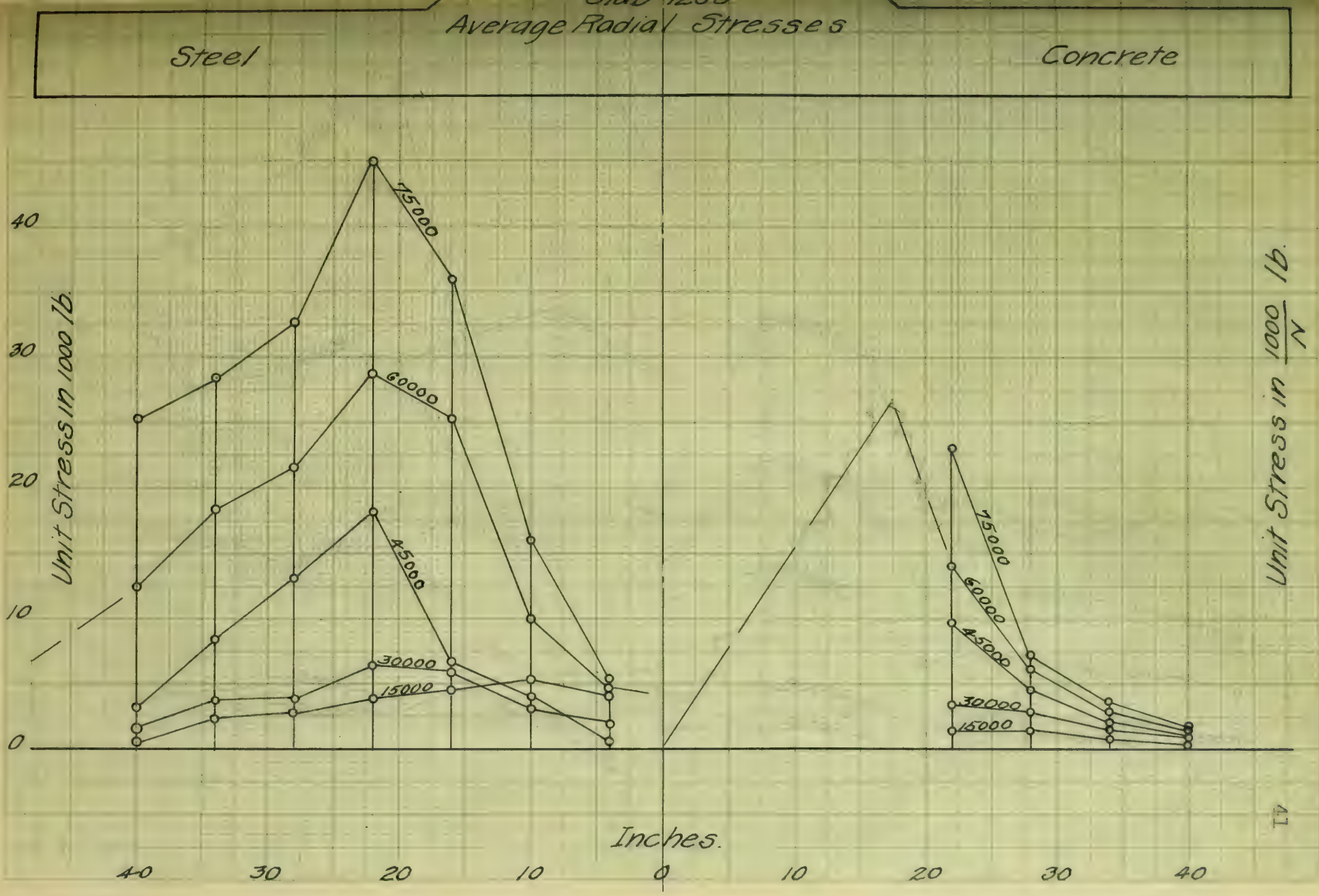
$A_s = 3.44.0"$

$p = .625\%$

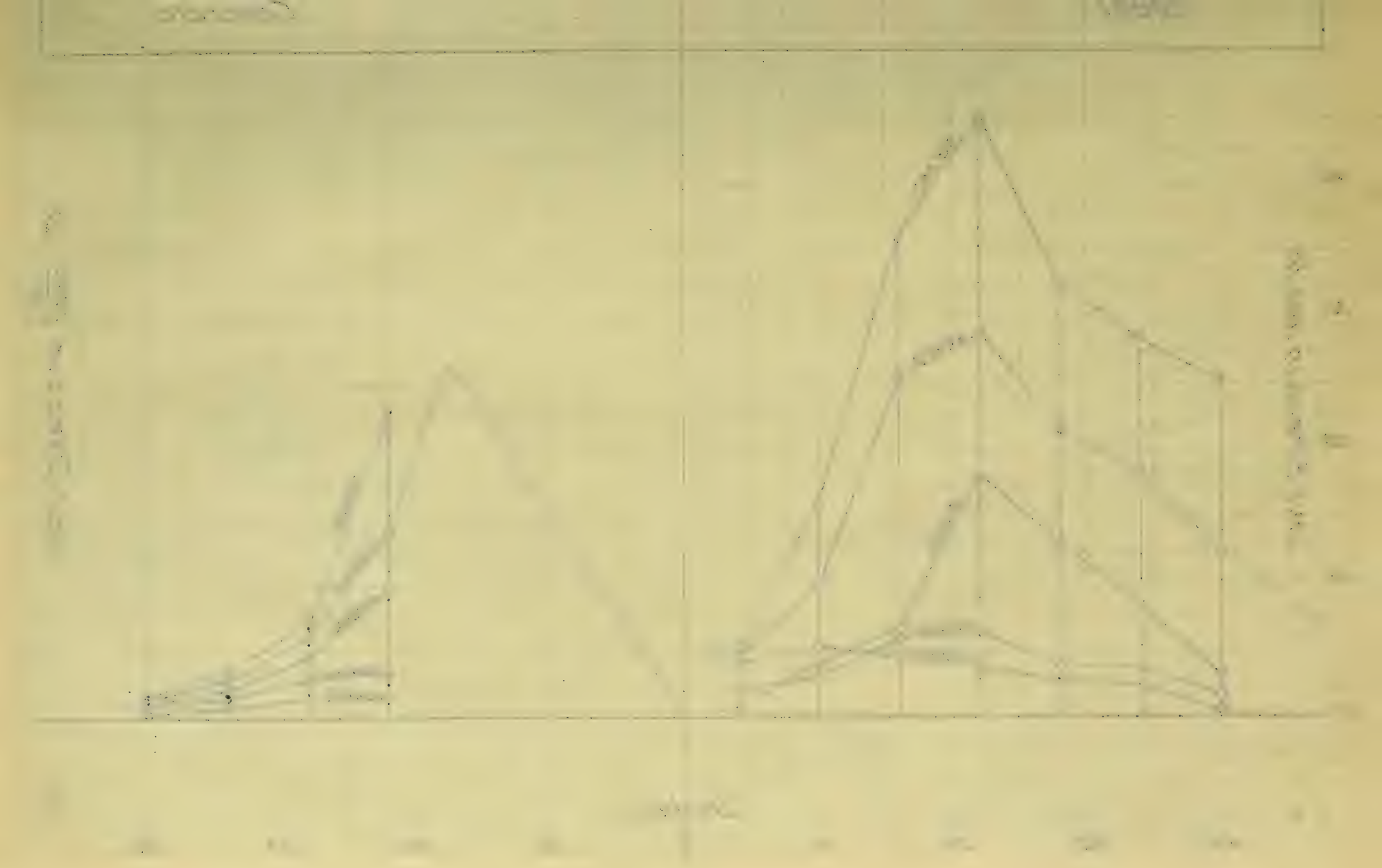
Sketch of Cracks. Slab ---1253 Figure 12.

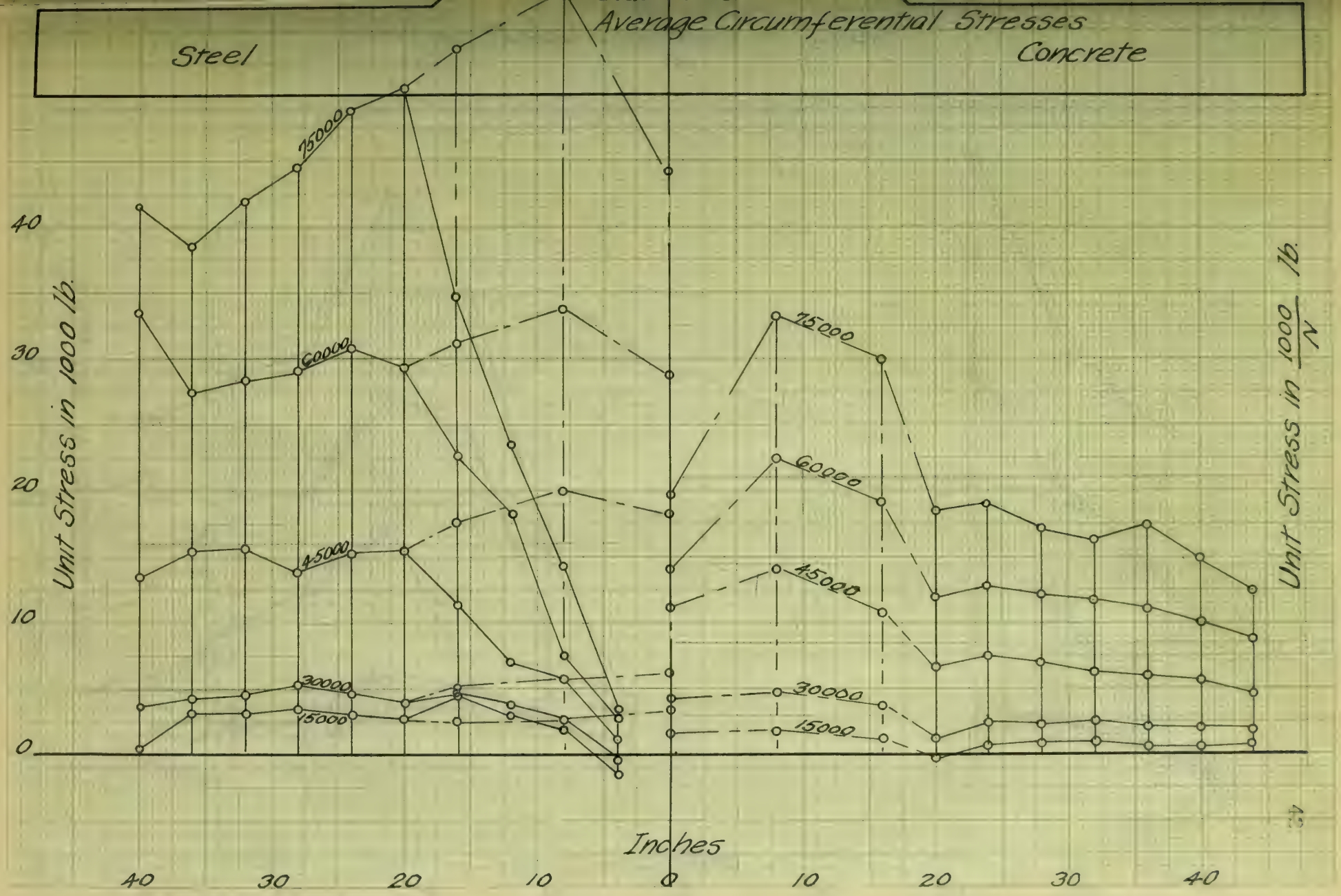


Average Radial Stresses



41



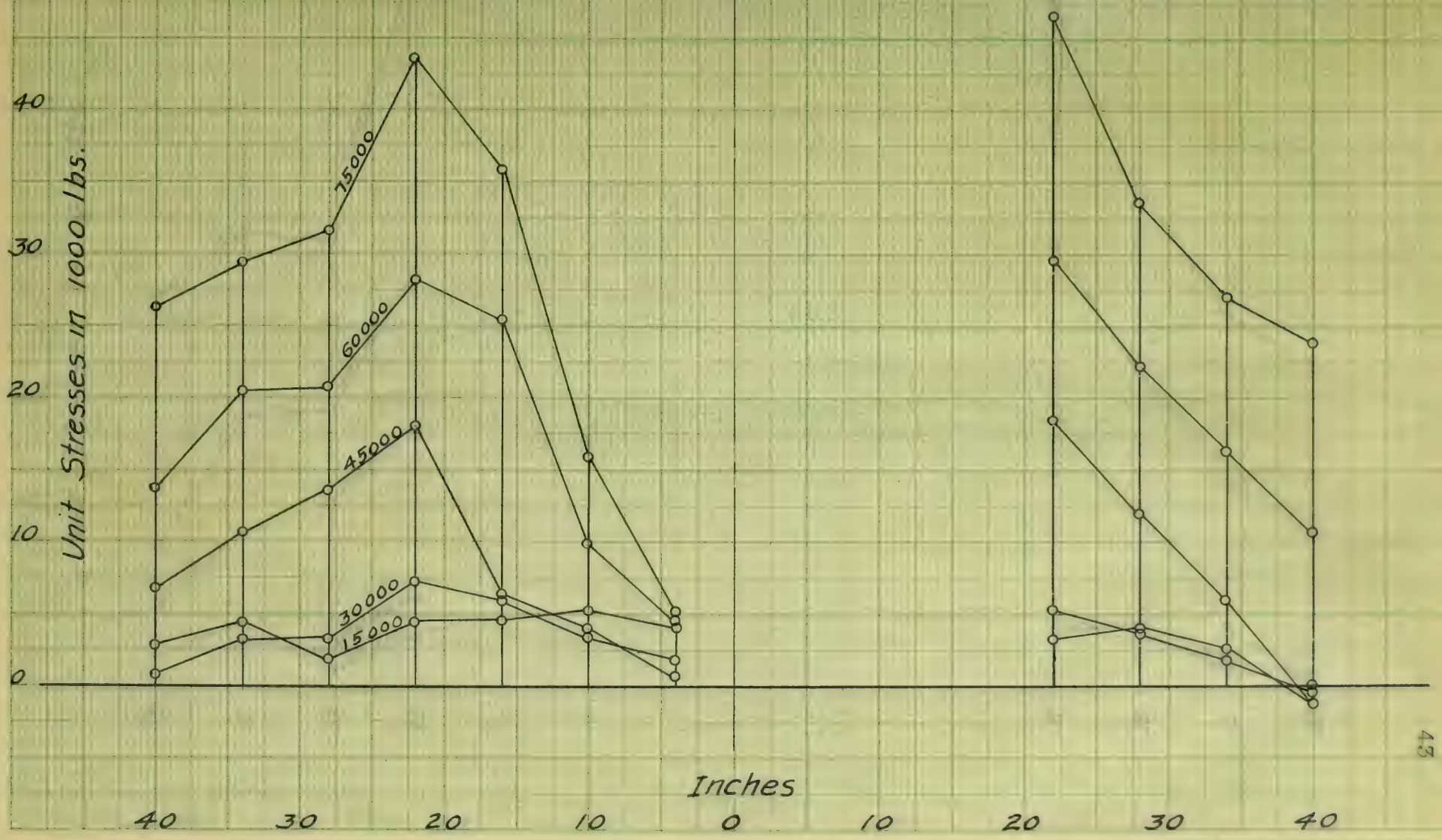

Average Circumferential Stresses
Steel
Concrete
75000
60000
45000
30000
15000
40
30
20
10
0
Unit Stress in 1000 lb.
Unit Stress in 1000/N lb.
Inches
40
30
20
10
0
10
20
30
40

Slab 1233

S-E

Average Radial Stresses in Steel

℄

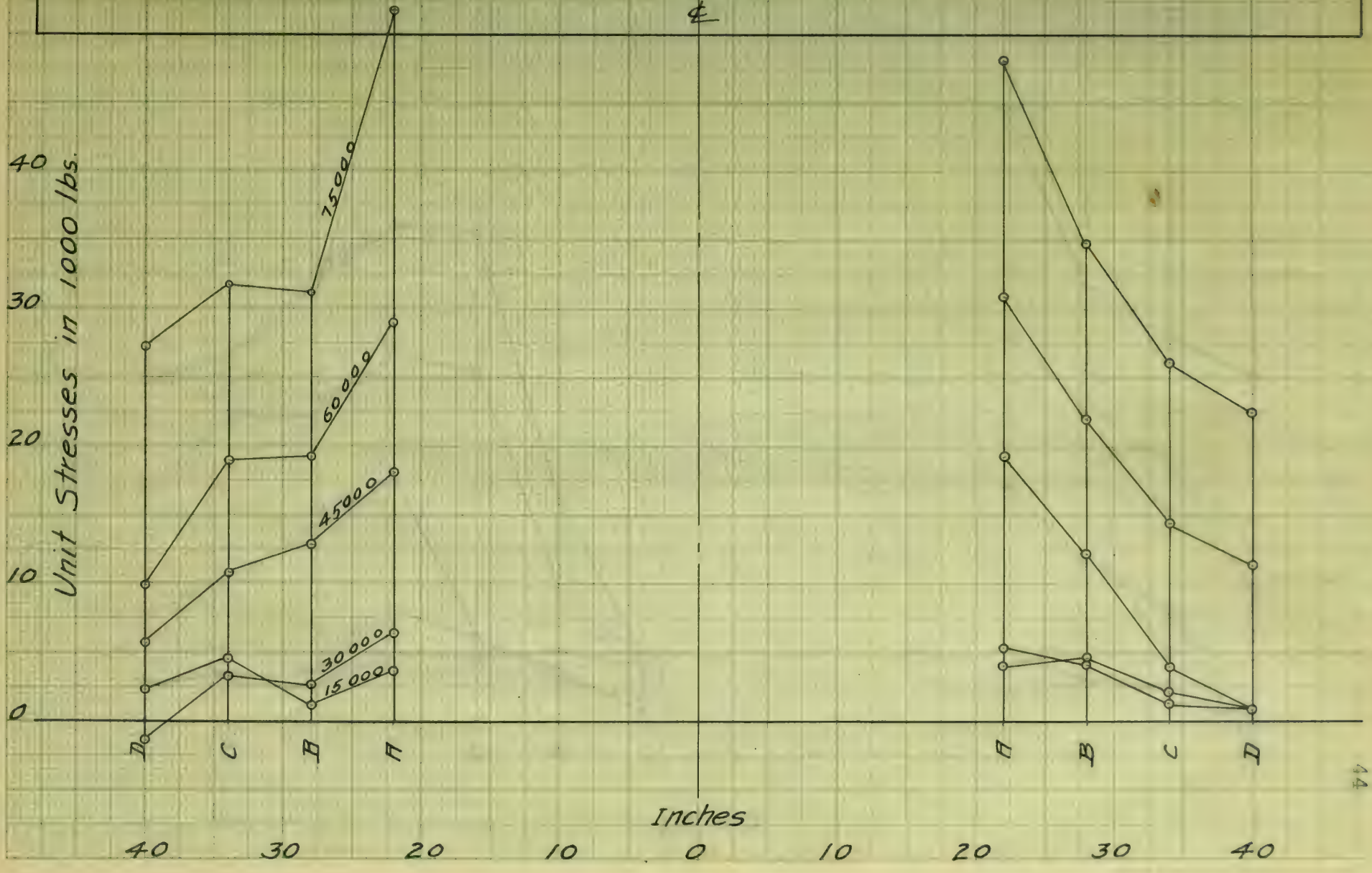


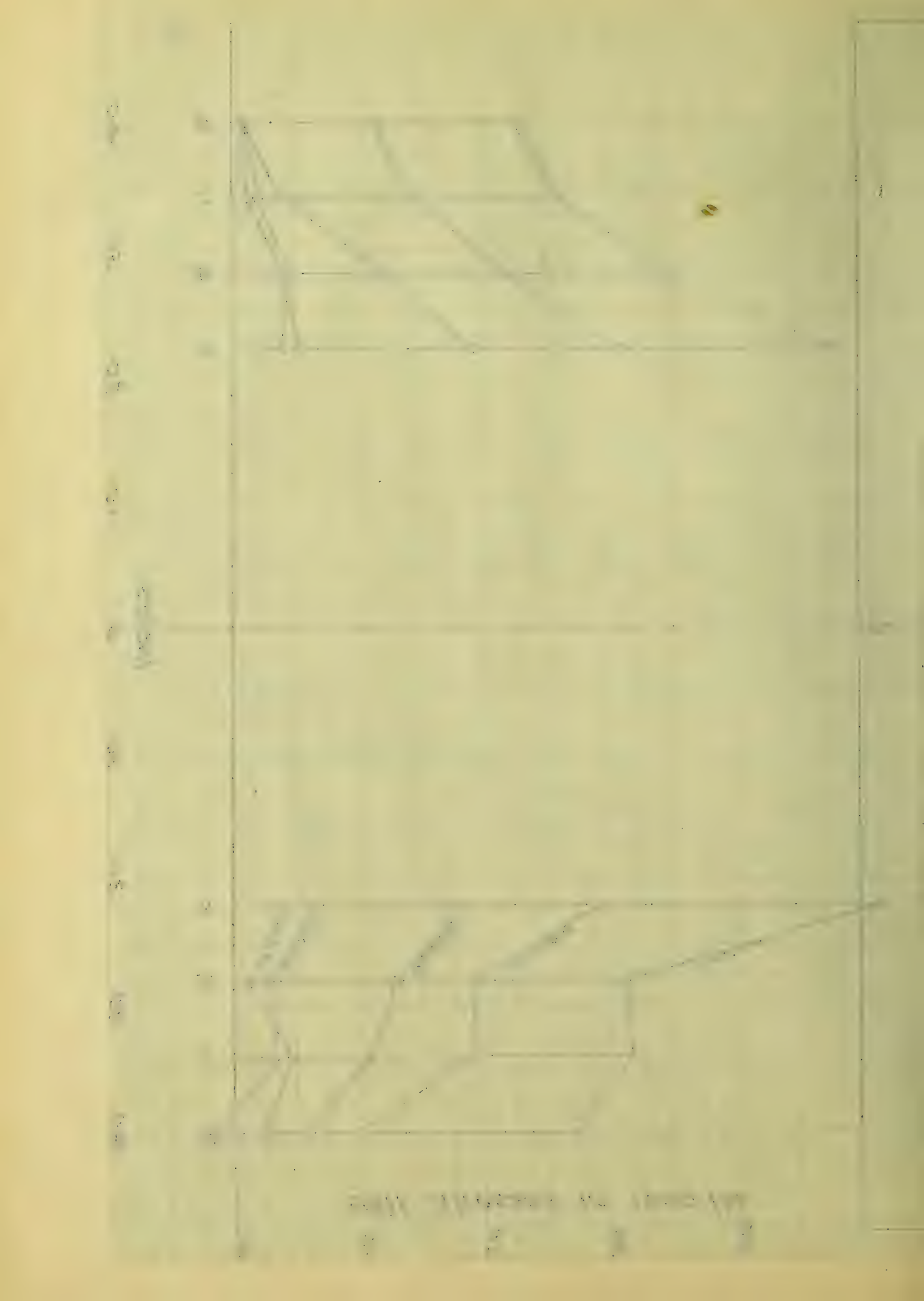
43

Slab 1253

E

Radial Stresses in Steel

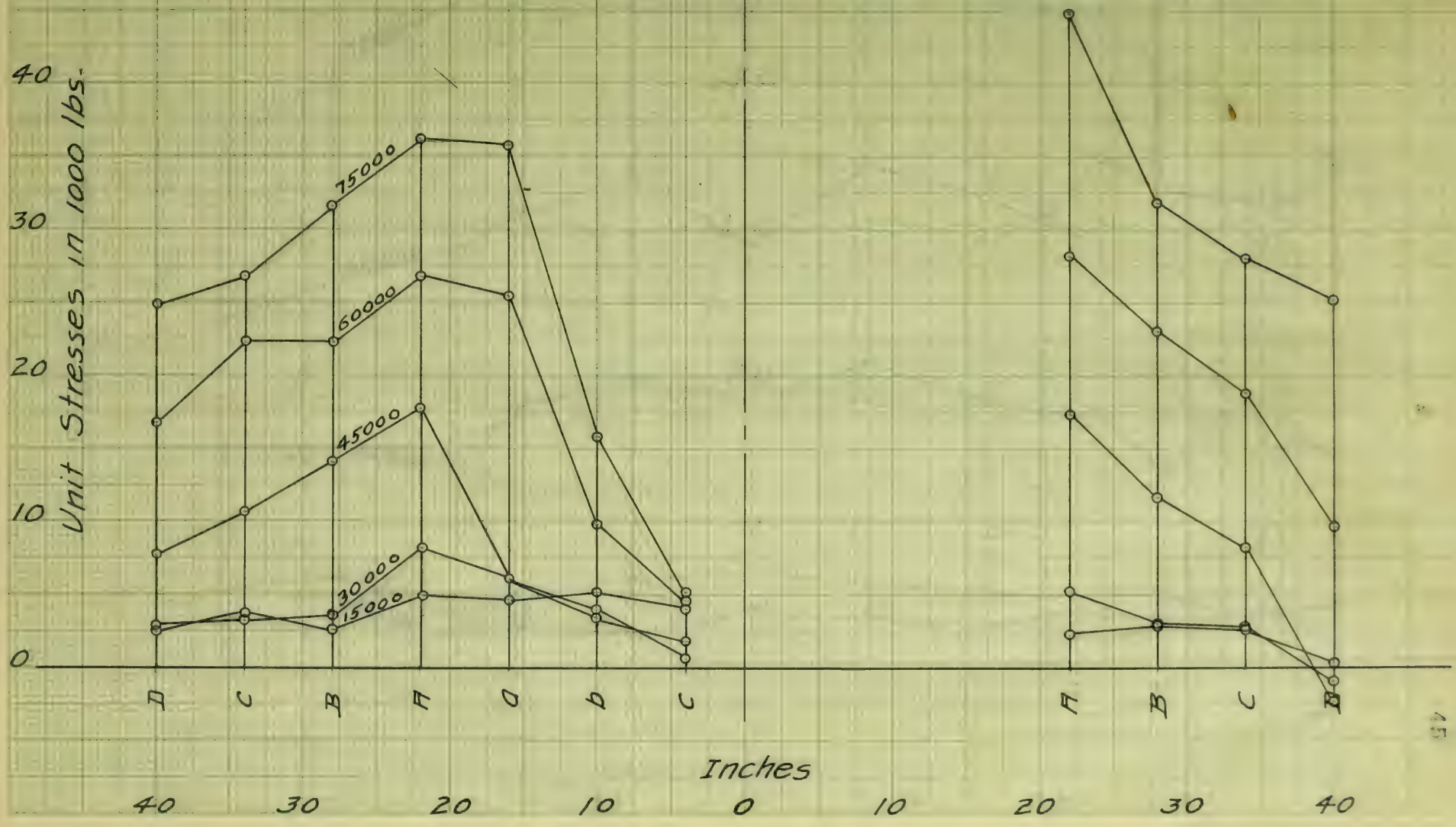


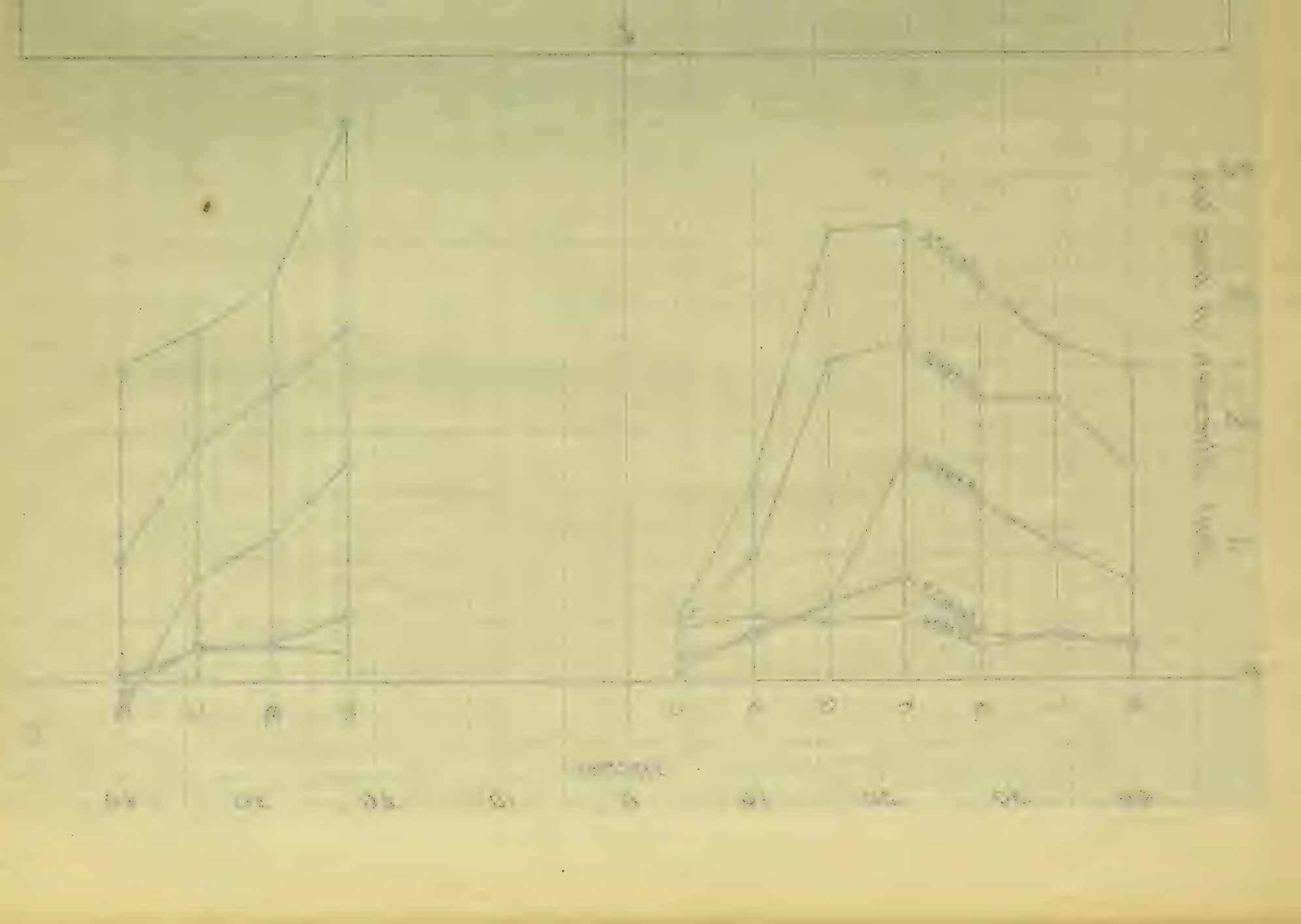


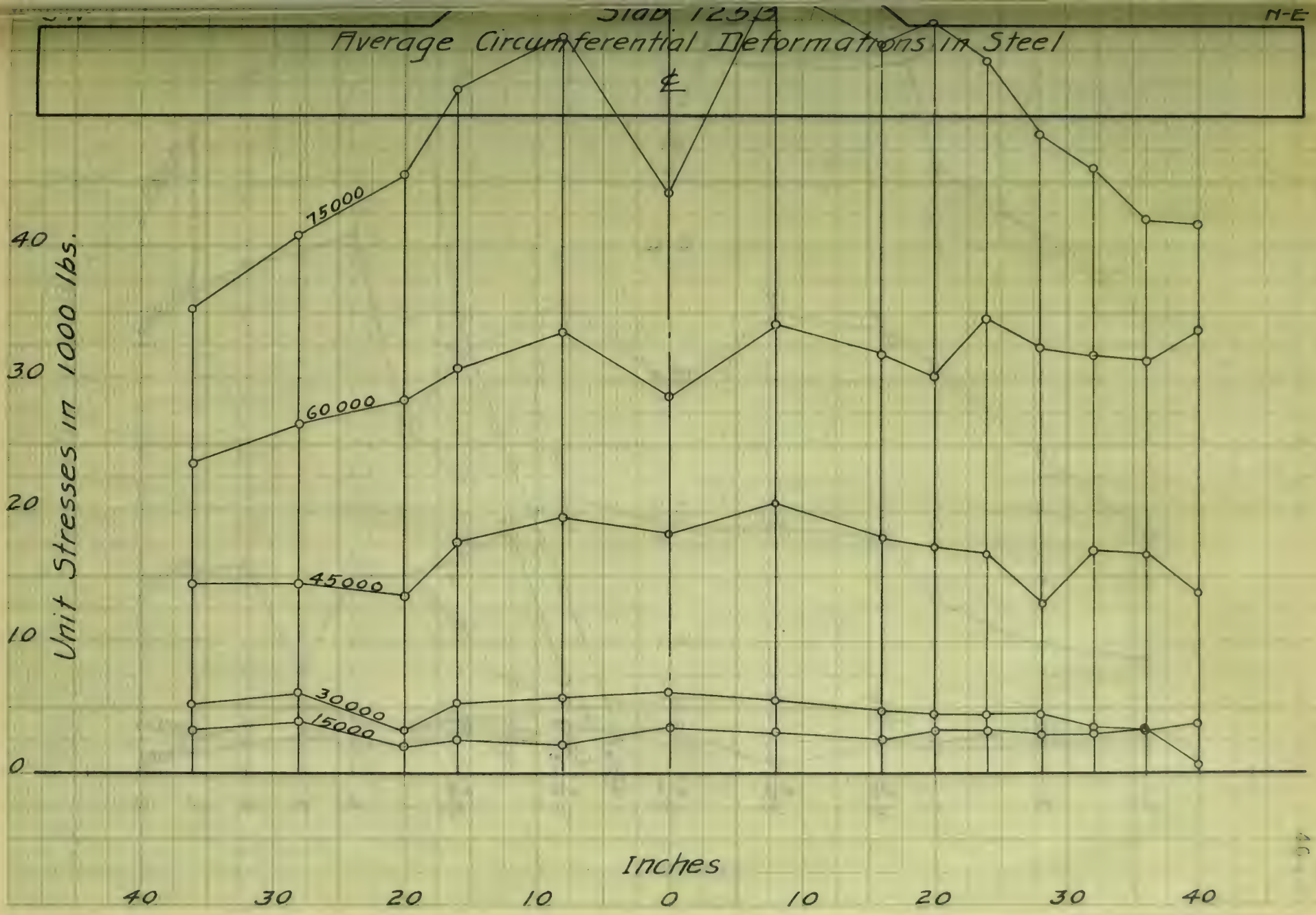
Slab 1253

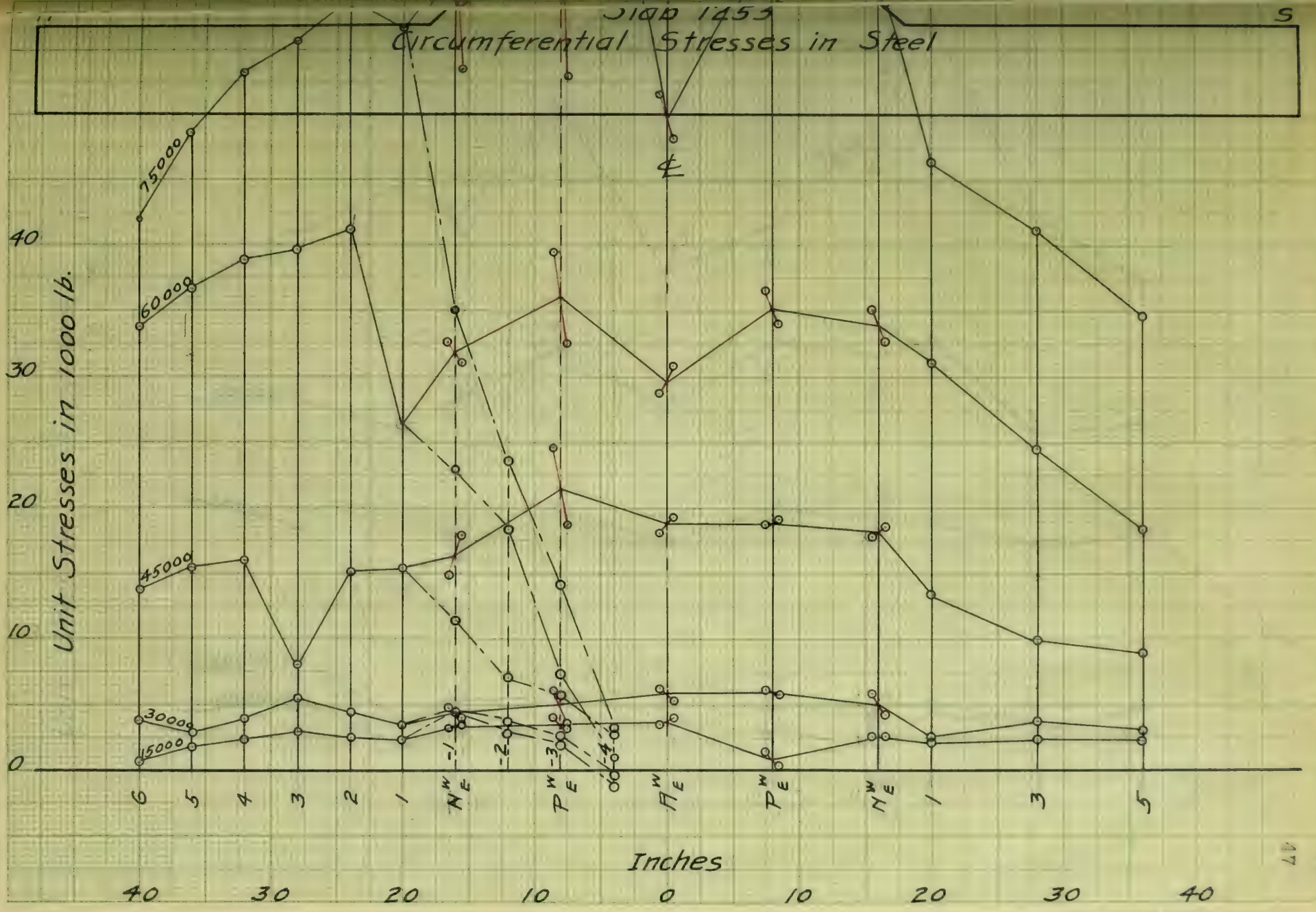
S

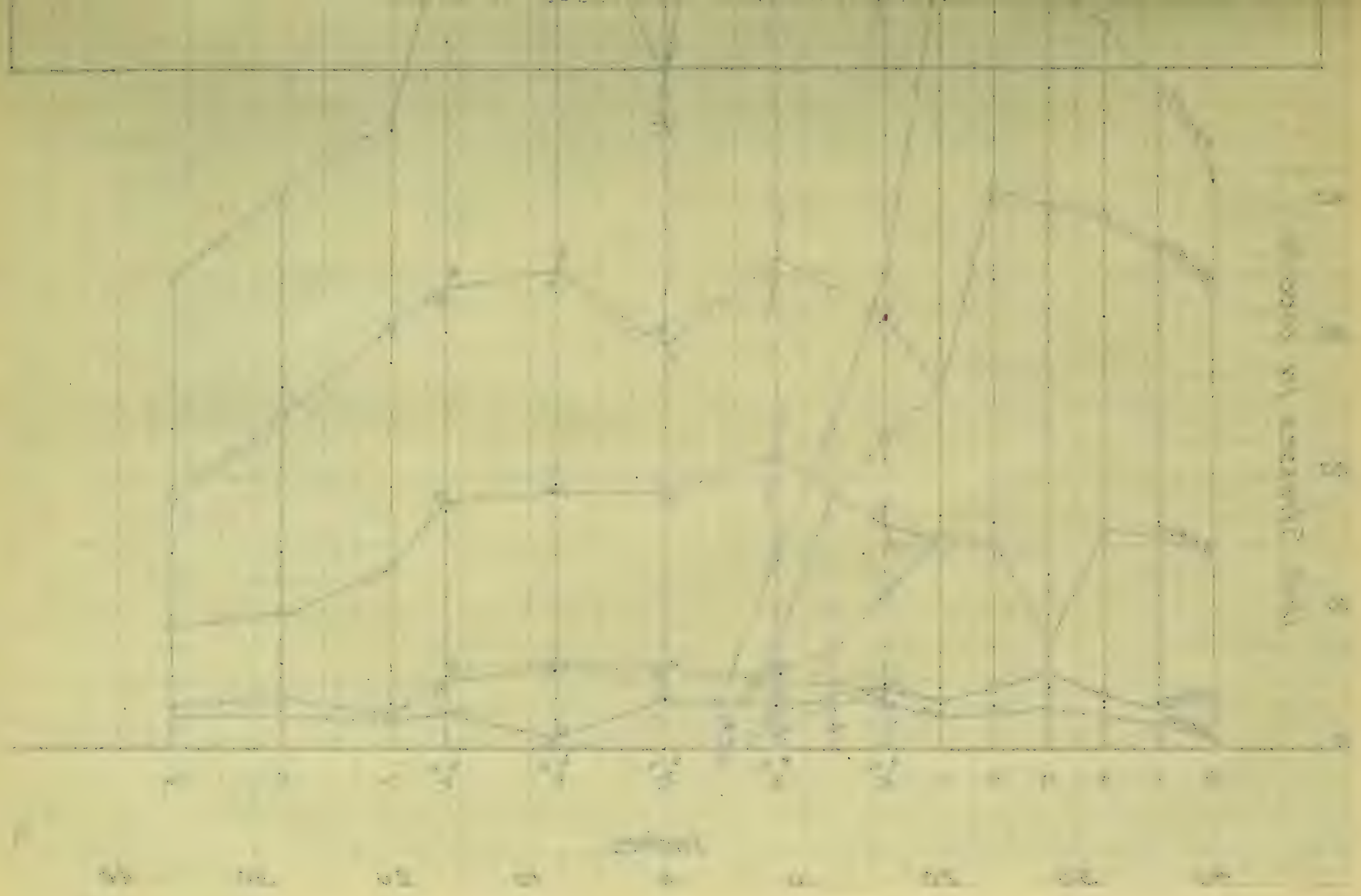
Radial Stresses in Steel

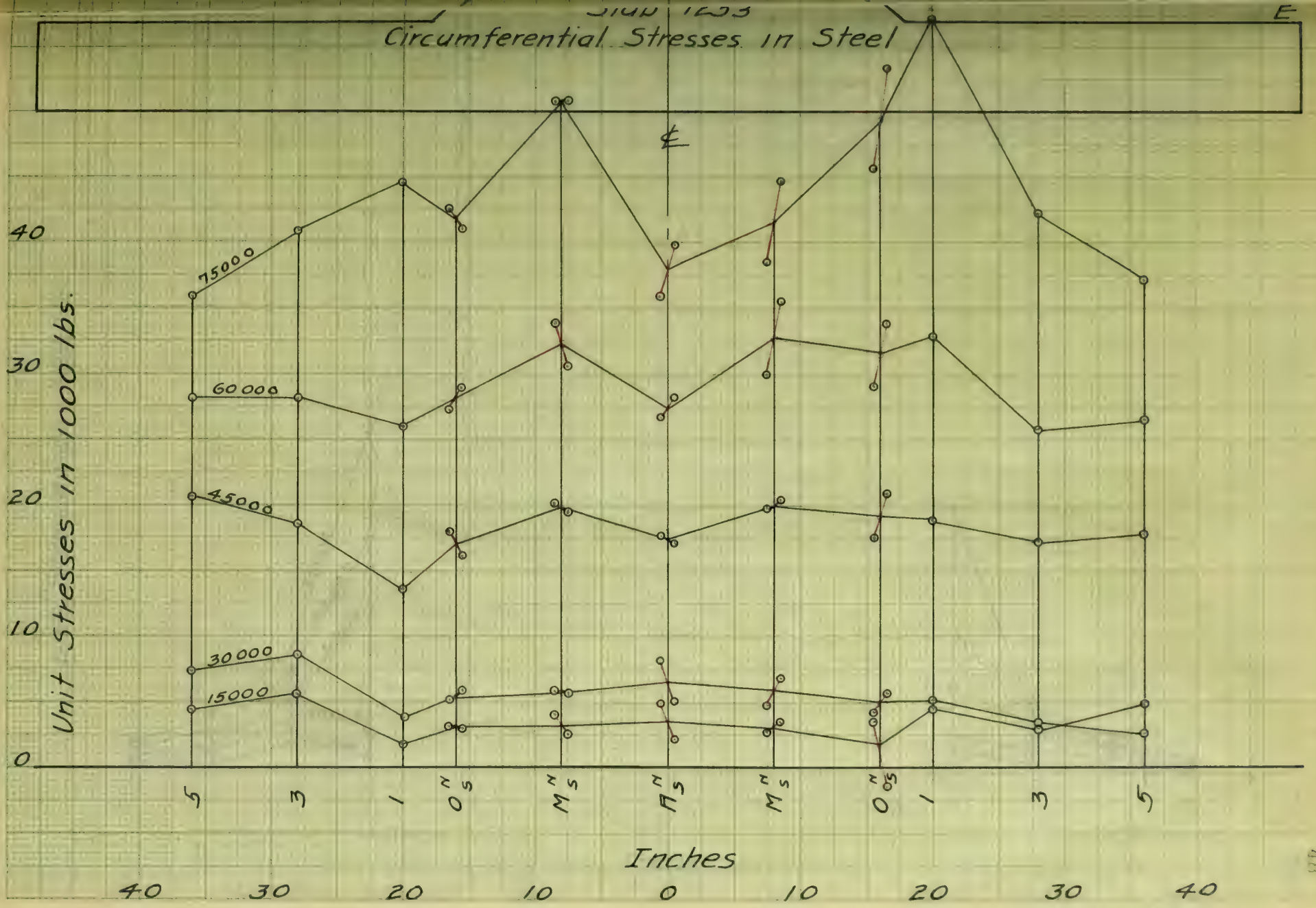


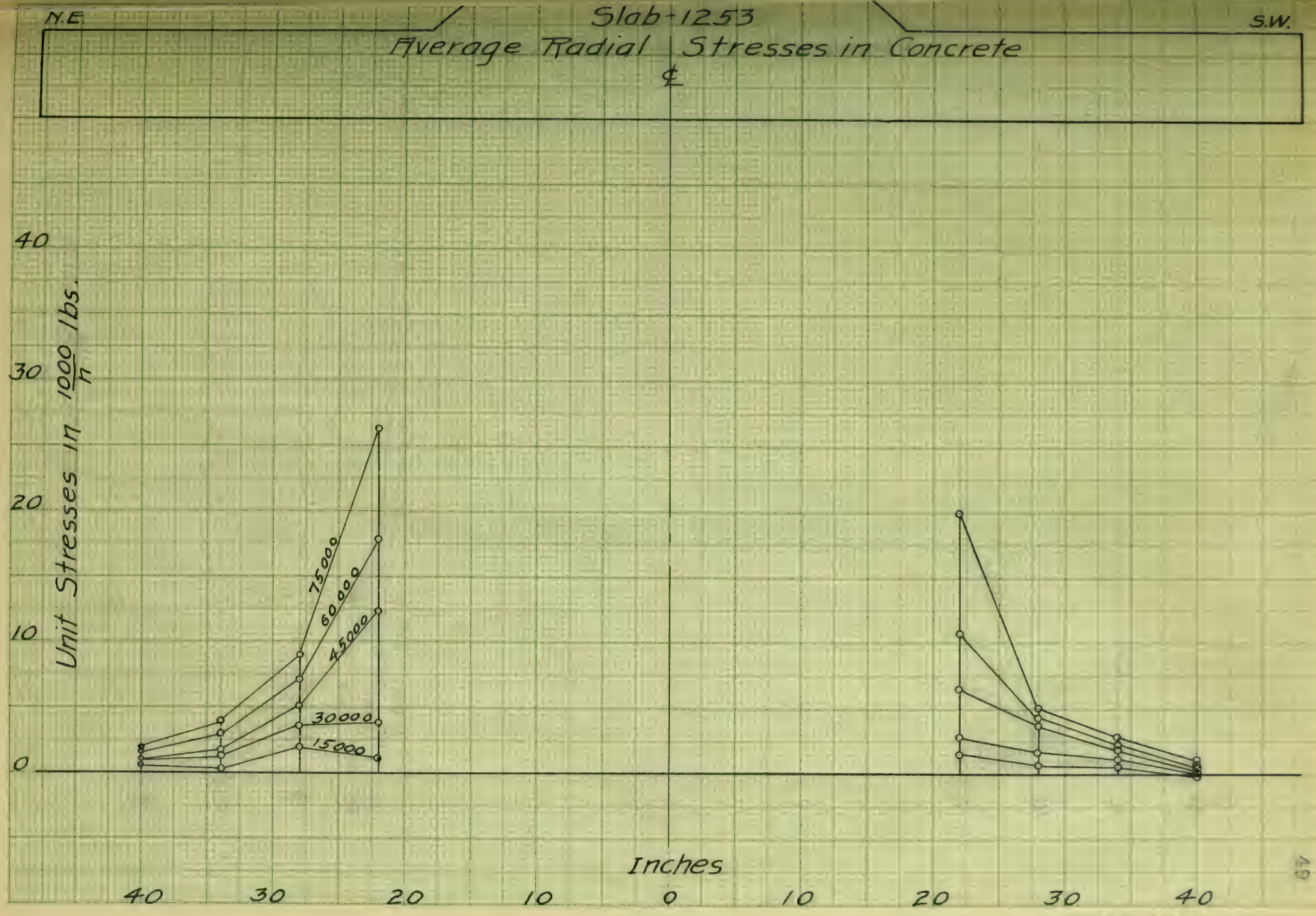


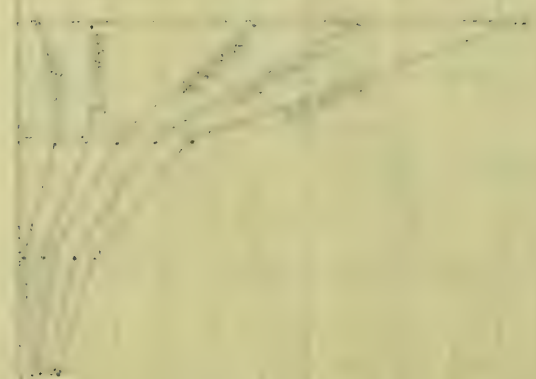

Average Circumferential Deformations in Steel
℄
75000
60000
45000
30000
15000
Unit Stresses in 1000 lbs.
40
30
20
10
0
Inches
40
30
20
10
0
10
20
30
40

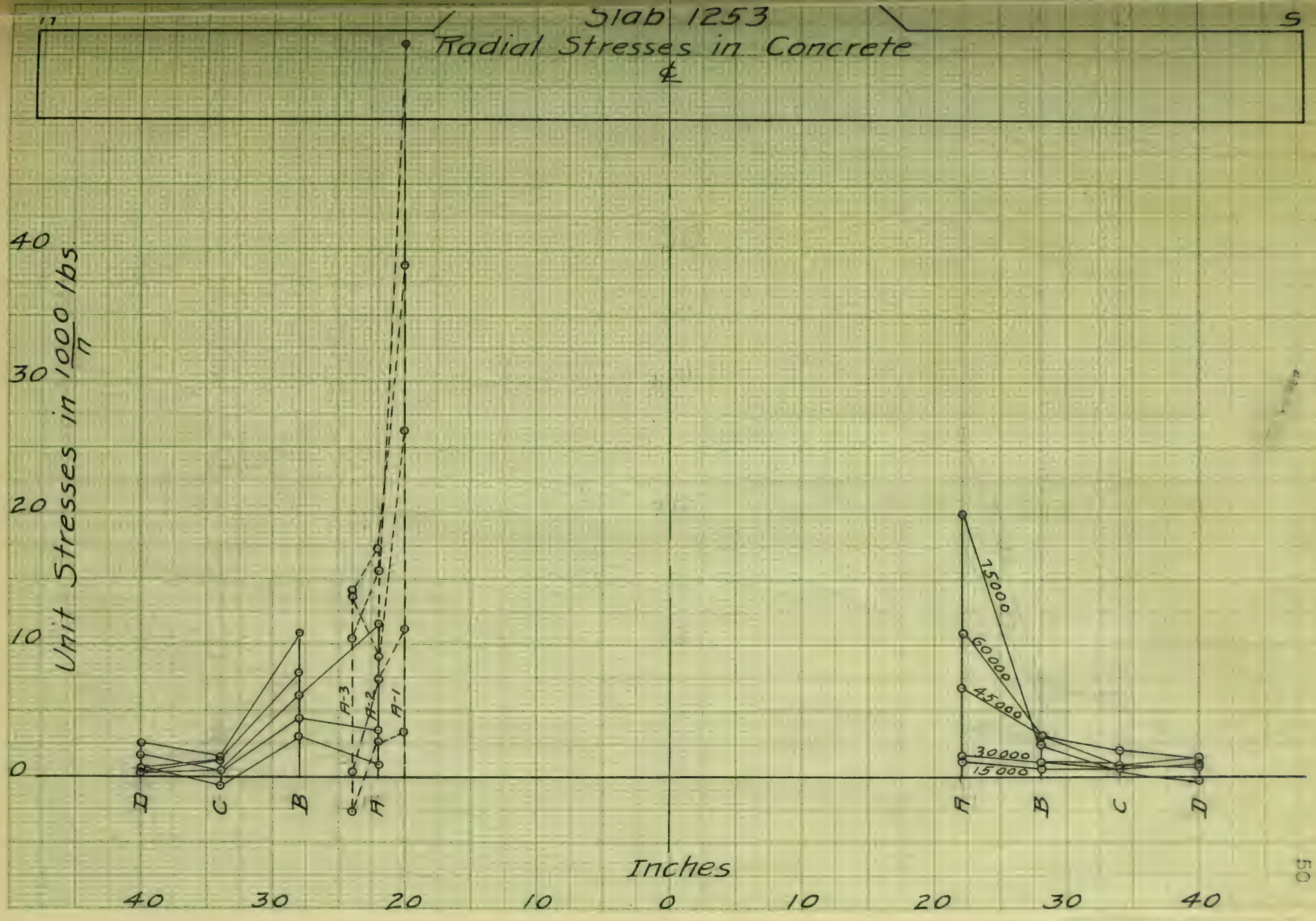

Circumferential Stresses in Steel
Unit Stresses in 1000 lb.
75000
60000
45000
30000
15000
40
30
20
10
0
6
5
4
3
2
1
N W E
P W E
A W E
P W E
N W E
1
3
5
-1
-2
-3
-4
Inches
40
30
20
10
0
10
20
30
40




Circumferential Stresses in Steel
E
℄
40
30
20
10
0
Unit Stresses in 1000 lbs.
75000
60000
45000
30000
15000
5
3
1
0 N S
M N S
A N S
M N S
0 N S
1
3
5
Inches
40
30
20
10
0
10
20
30
40


N.E
Slab-1253
S.W.
Average Radial Stresses in Concrete
℄
40
30
20
10
0
Unit Stresses in 1000 lbs. per sq. in.
75000
60000
45000
30000
15000
Inches
40
30
20
10
0
10
20
30
40

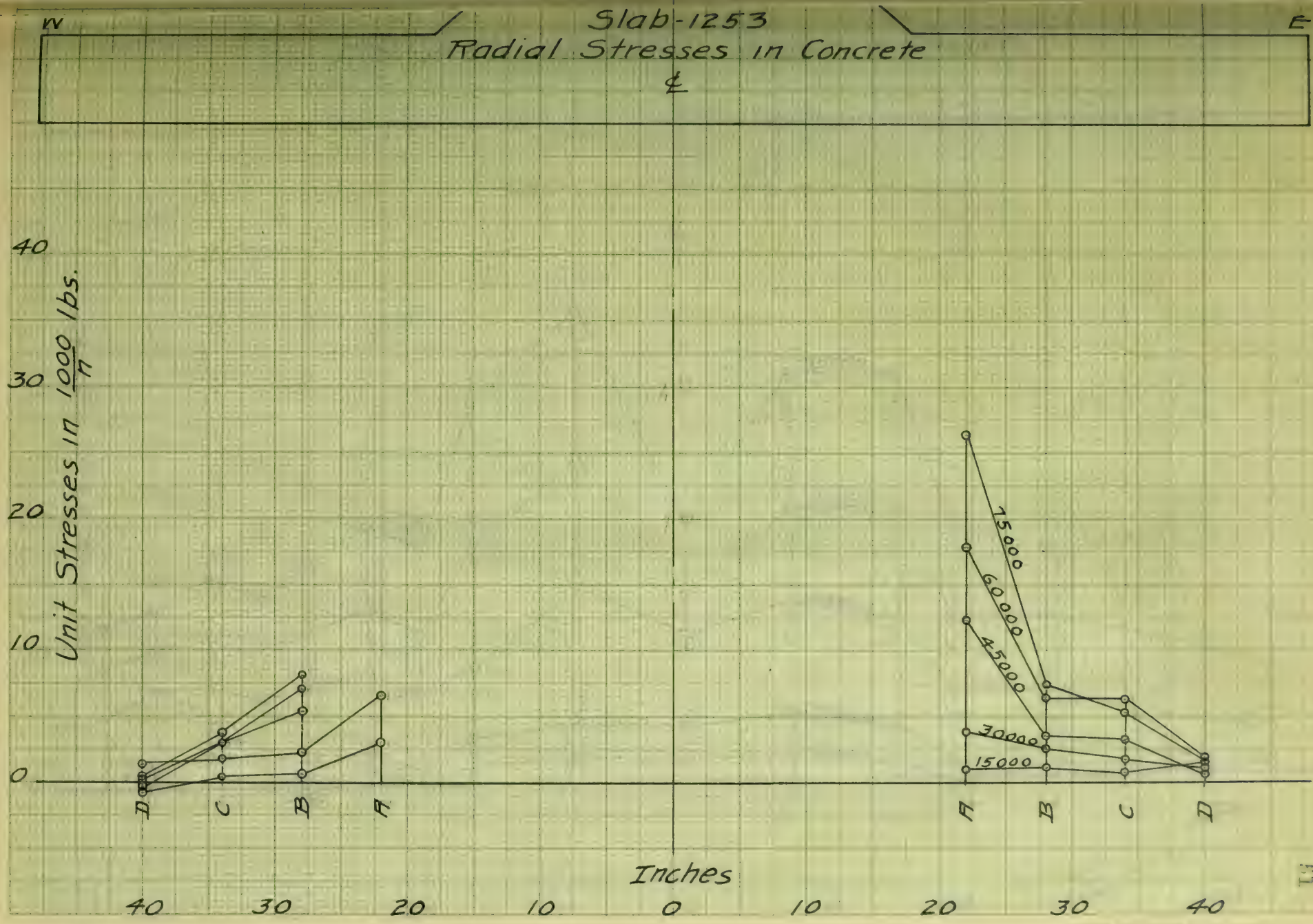



Slab 1253
Radial Stresses in Concrete
℄
Unit Stresses in 1000 lbs. / in
40
30
20
10
0
A-3
A-2
A-1
D
C
B
A
75000
60000
45000
30000
15000
A
B
C
D
Inches
40
30
20
10
0
10
20
30
40

W

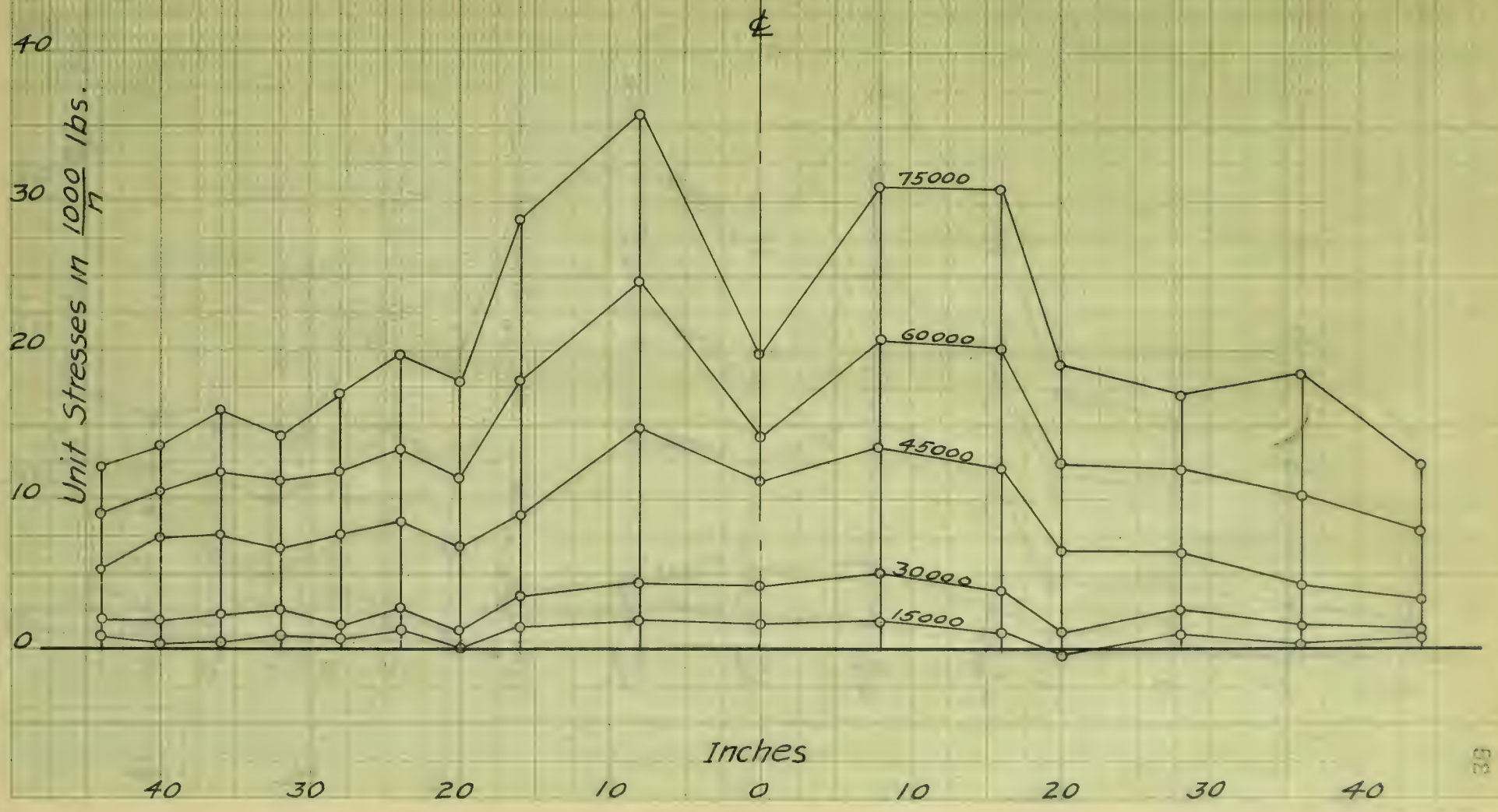
Slab-1253
Radial Stresses in Concrete
&

E

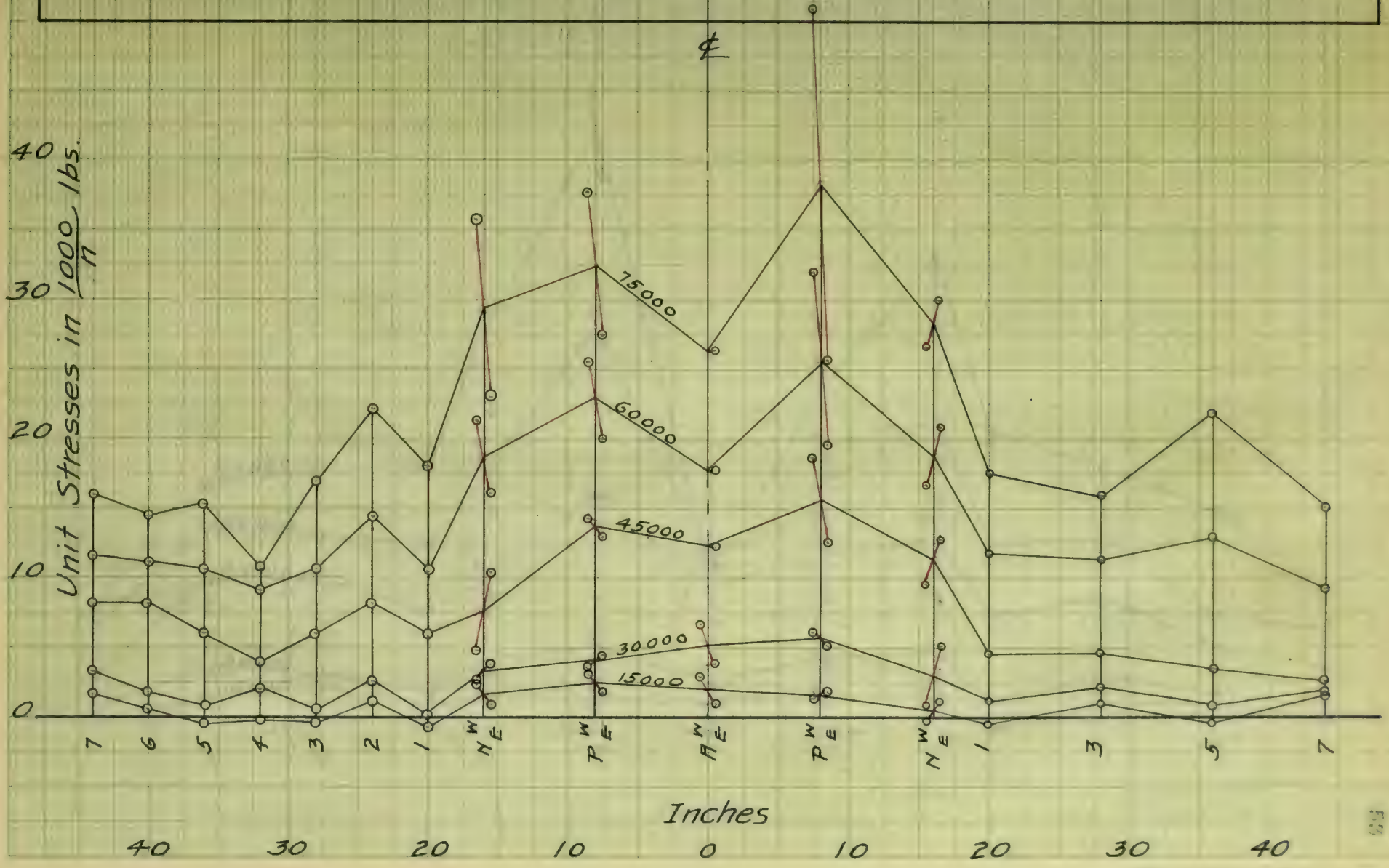


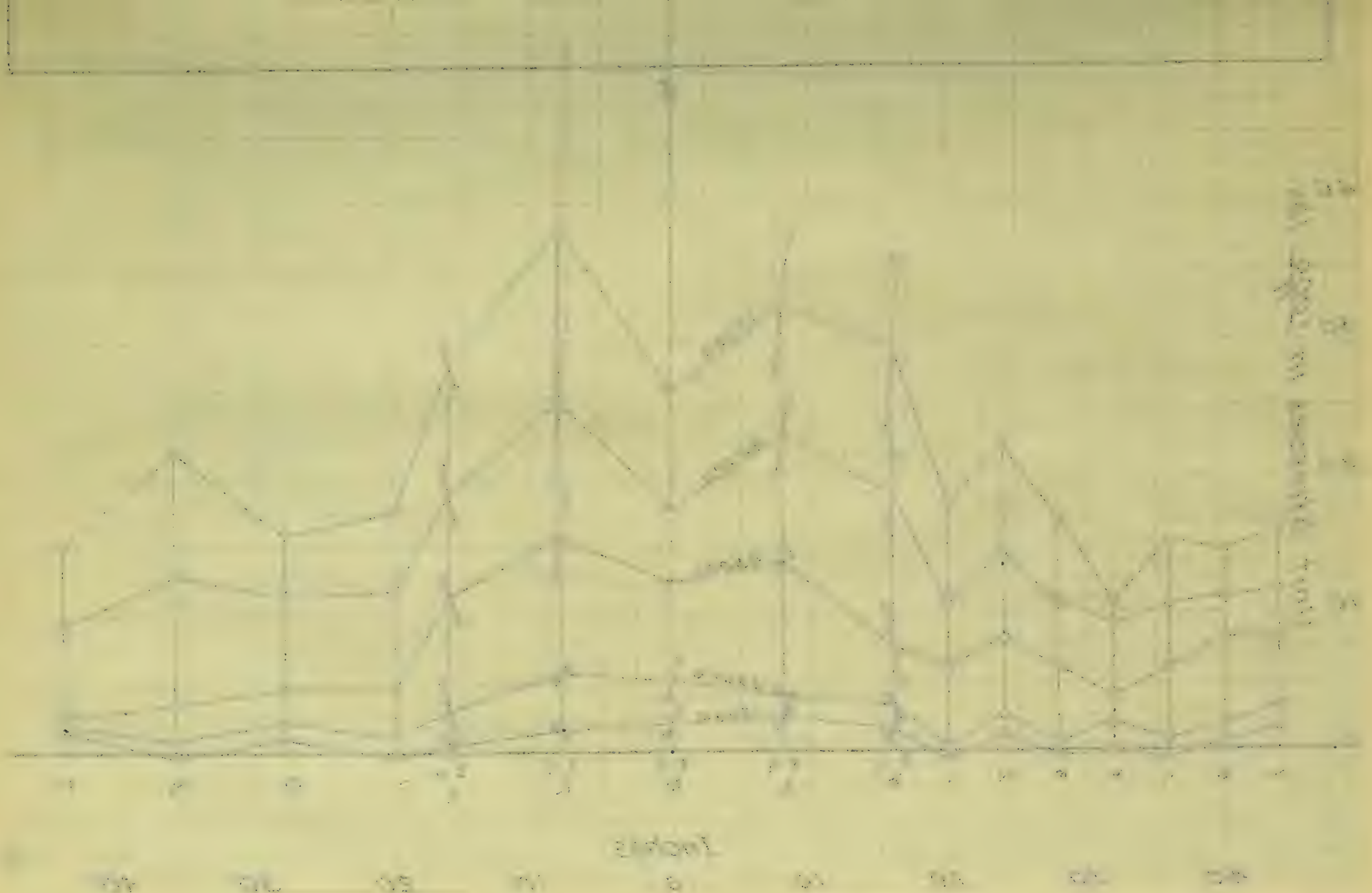
W-17

Average Circumferential Stresses in Concrete



Circumferential Stresses in Concrete

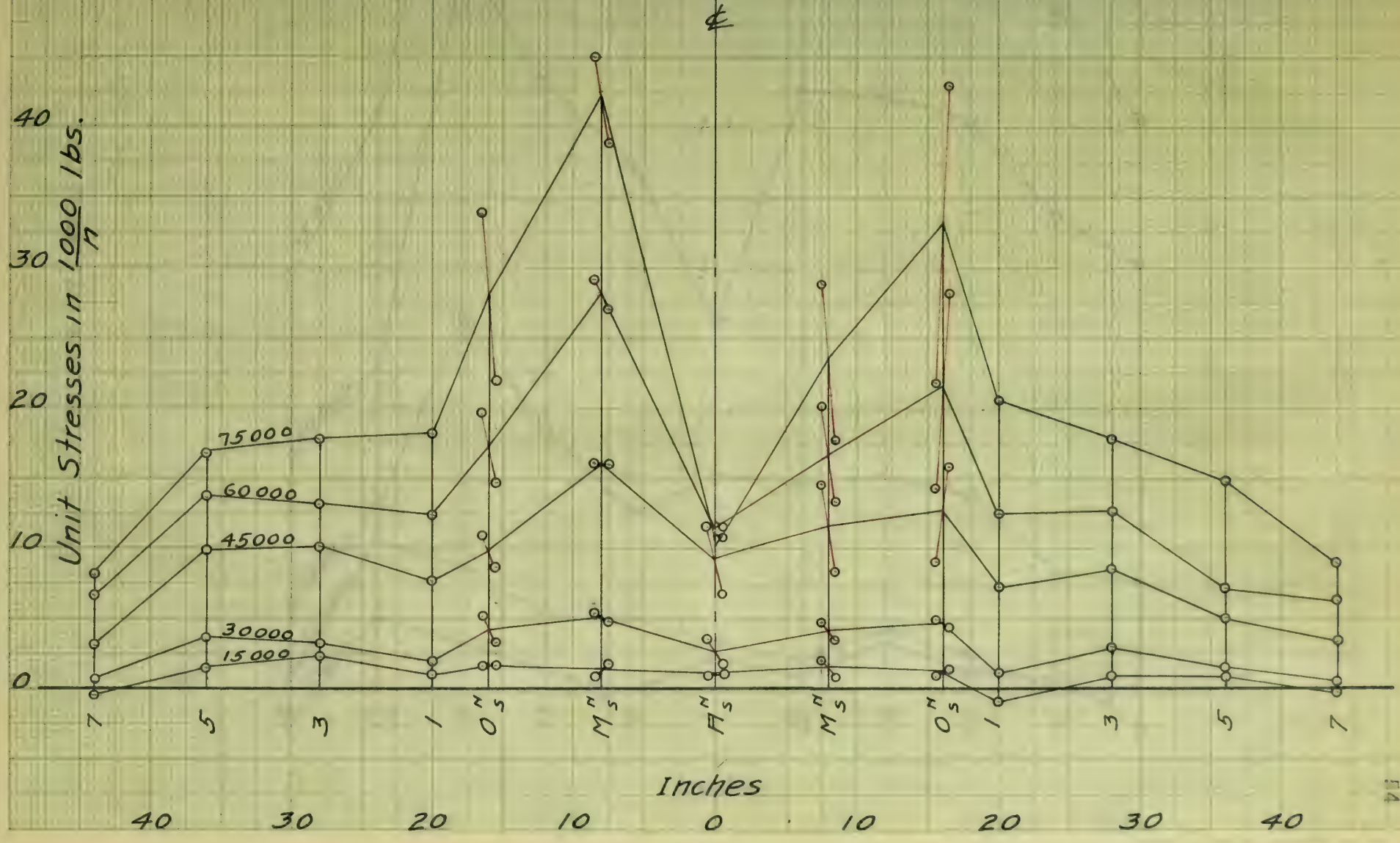




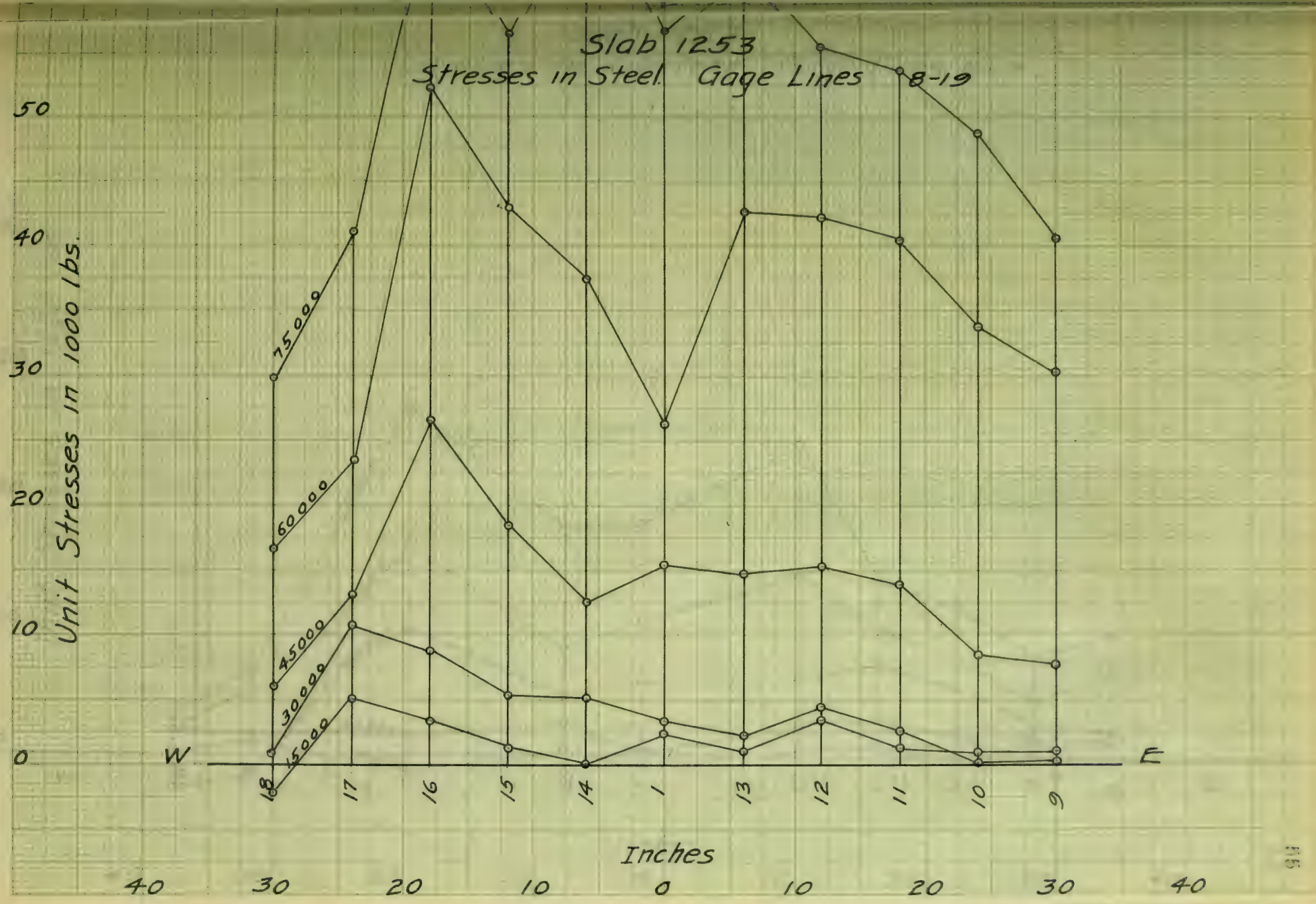
Study 1233

E

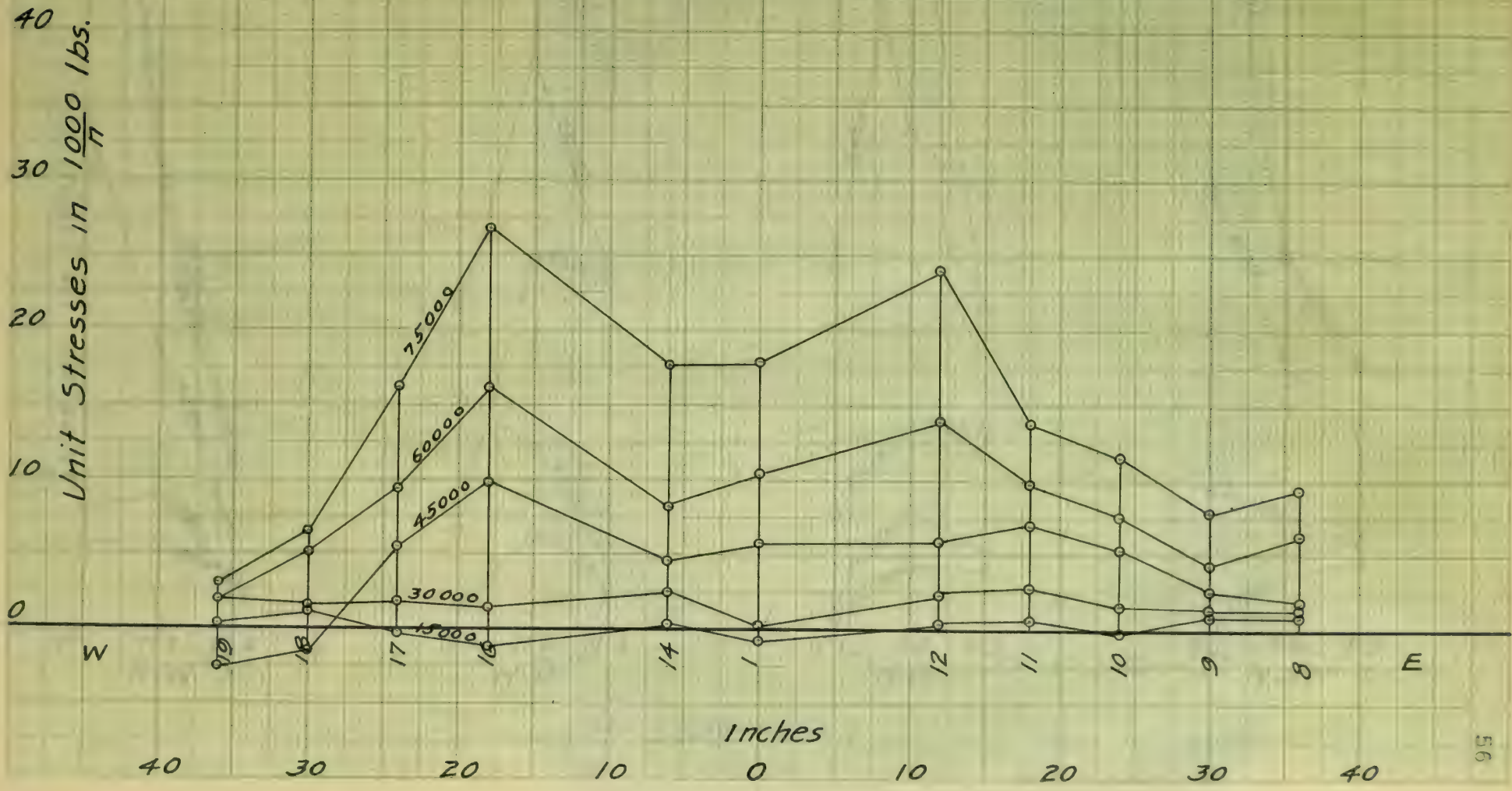
Circumferential Stresses in Concrete

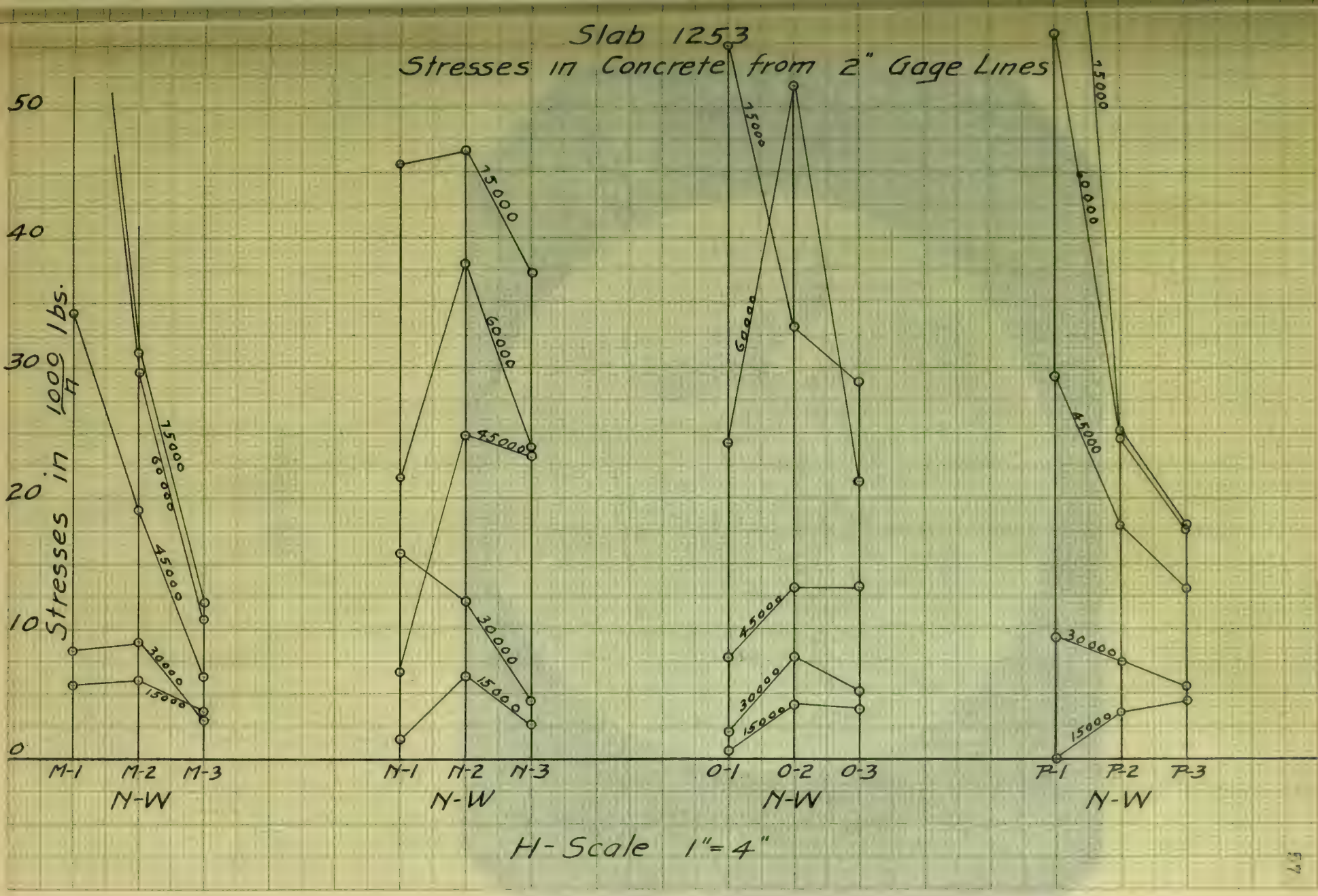


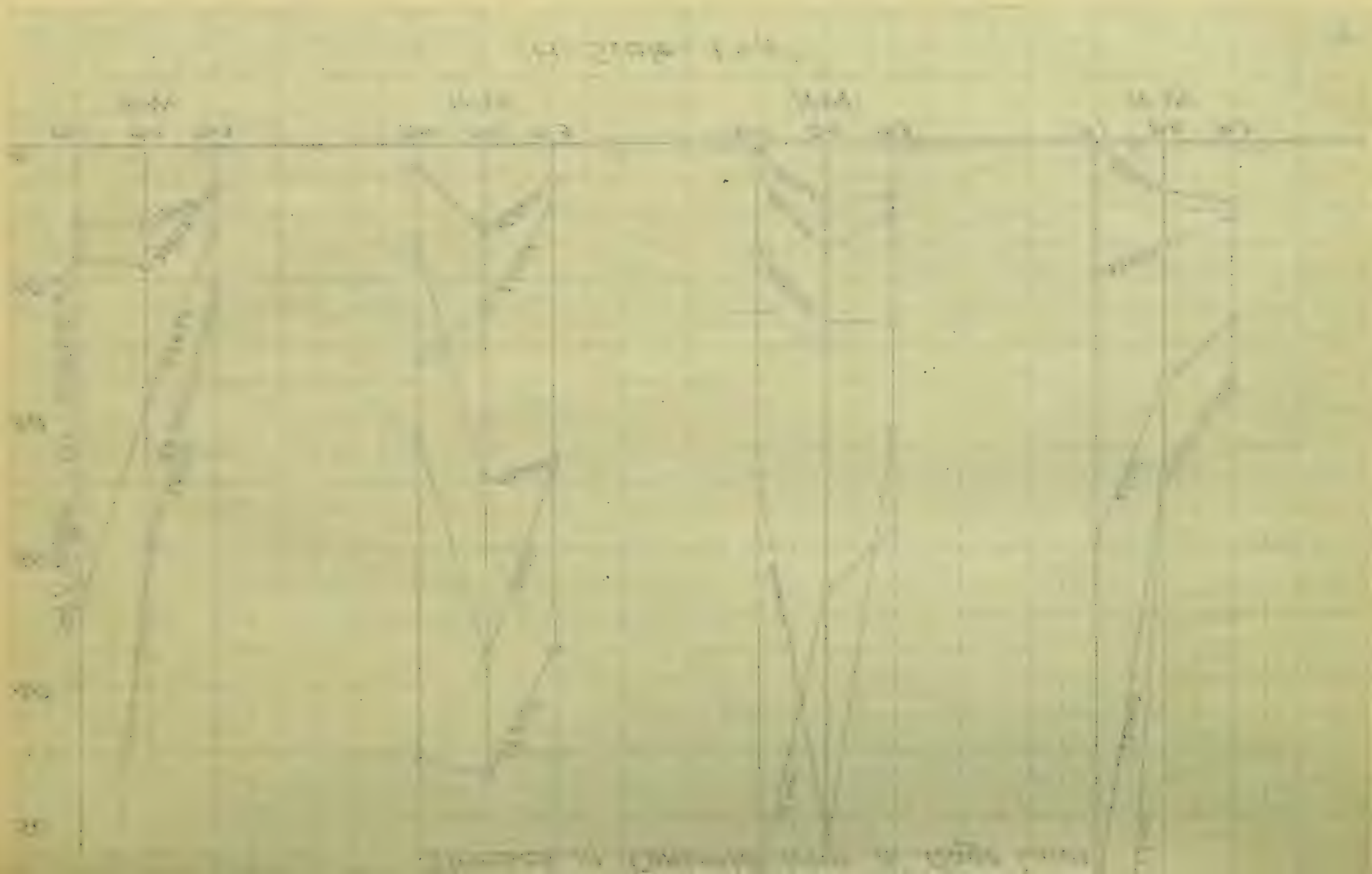
E4


Slab 1253
Stresses in Steel. Gage Lines 8-19
Unit Stresses in 1000 lbs.
50
40
30
20
10
0
75000
60000
45000
30000
15000
W
E
18
17
16
15
14
1
13
12
11
10
9
Inches
40
30
20
10
0
10
20
30
40

Slab-1253
Stresses in Concrete. Gage Lines 8-19.




Slab 1253
Stresses in Concrete from 2" Gage Lines
Stresses in 1000 lbs. per H
50
40
30
20
10
0
75000
60000
45000
30000
15000
M-1
M-2
M-3
N-W
N-1
N-2
N-3
N-W
O-1
O-2
O-3
N-W
P-1
P-2
P-3
N-W
H-Scale 1"=4"



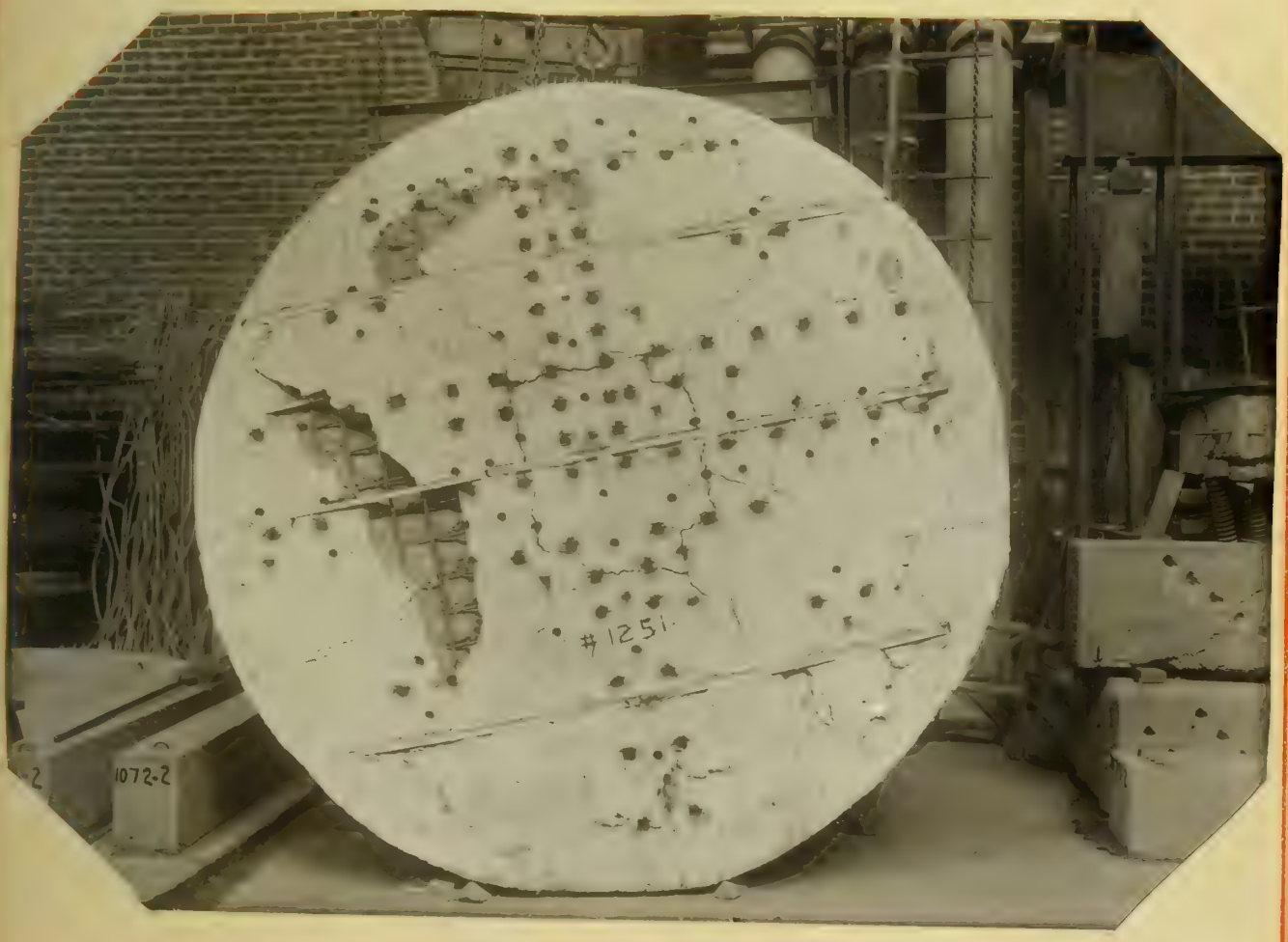


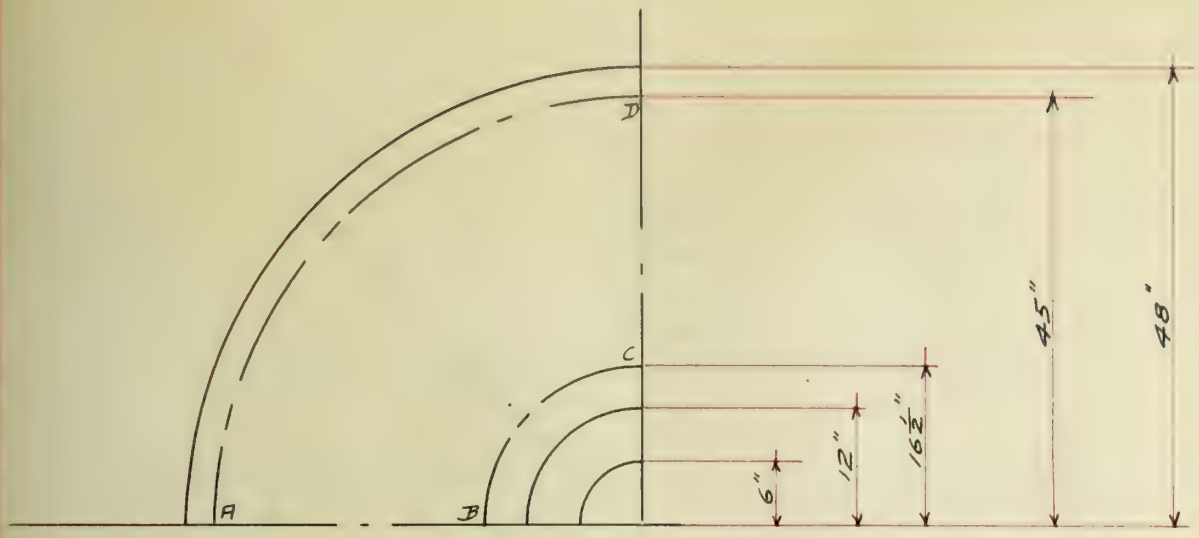
Figure 13.

VIEW OF BLAB " AUTI WATER TEST [illegible].

B. [illegible]

17. Elements of Tests. Slab [illegible] reinforcement and [illegible]. But the primary and the final cause of the failure of the specimen was tension in the steel. At the ultimate load of 73000 pounds the slab had a very large deformation and all the cracks had opened about 3/16 inches.

18. Load Deformation Relations. The deformations in the steel were larger in this slab for given loads than they were in any of the other slabs. This seems to be evidence of the fact that the concrete section as a whole is acting as a couple against the steel section as a whole and that that stress in the steel at any given point in a section does not necessarily need to be equal to the total concrete stress over the corresponding area. The question might here well be raised, whether the decrease in the strength of this slab is due to the smaller section around the cap which is available for resisting the radial stresses in the concrete or whether it is due to the decrease in the amount of concrete area in any any diametral section which is available for carrying circumferential stresses.



Slab 1251.

Equilibrium Calculations.

The bending moment equals $.707(45-16\frac{1}{2})45000$ or 227000 inch pounds in the direction CD on the section ABC. ($W = 45000$ #)

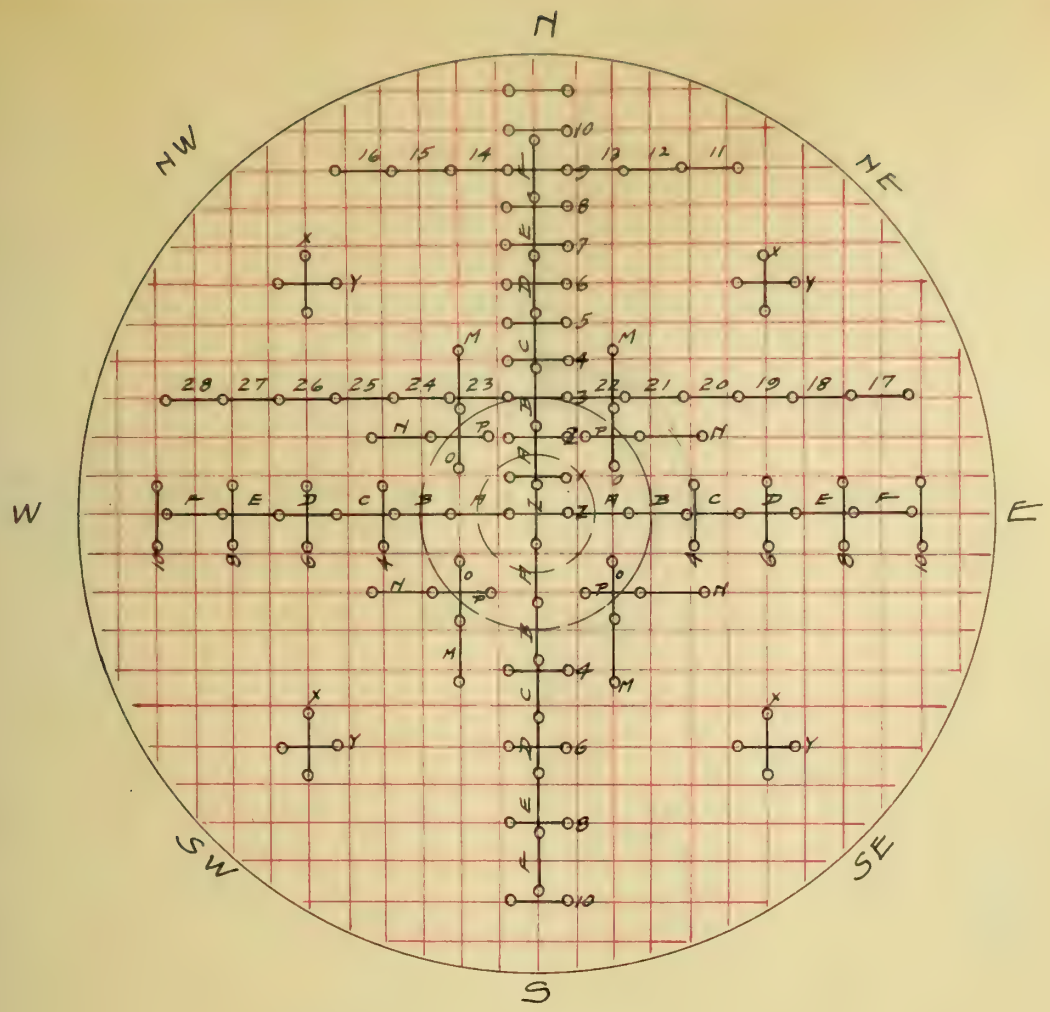
$11\frac{1}{2}$-7/16 inch diam. rods cut the section.

A_s equals 1.73 sq. inches.

The average steel stress for a load of 45000 pounds equals 21000 pounds per sq. inch on all the rods cutting the section ABC in the direction CD.

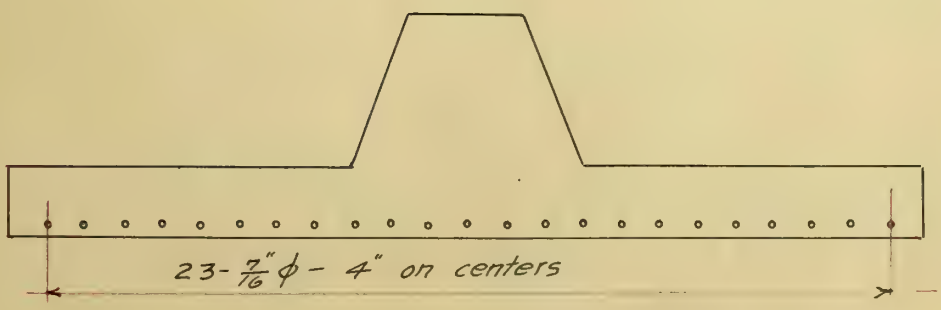
Therefore the effective depth or jD becomes 227000/1.63(21000) or 6.25 inches.

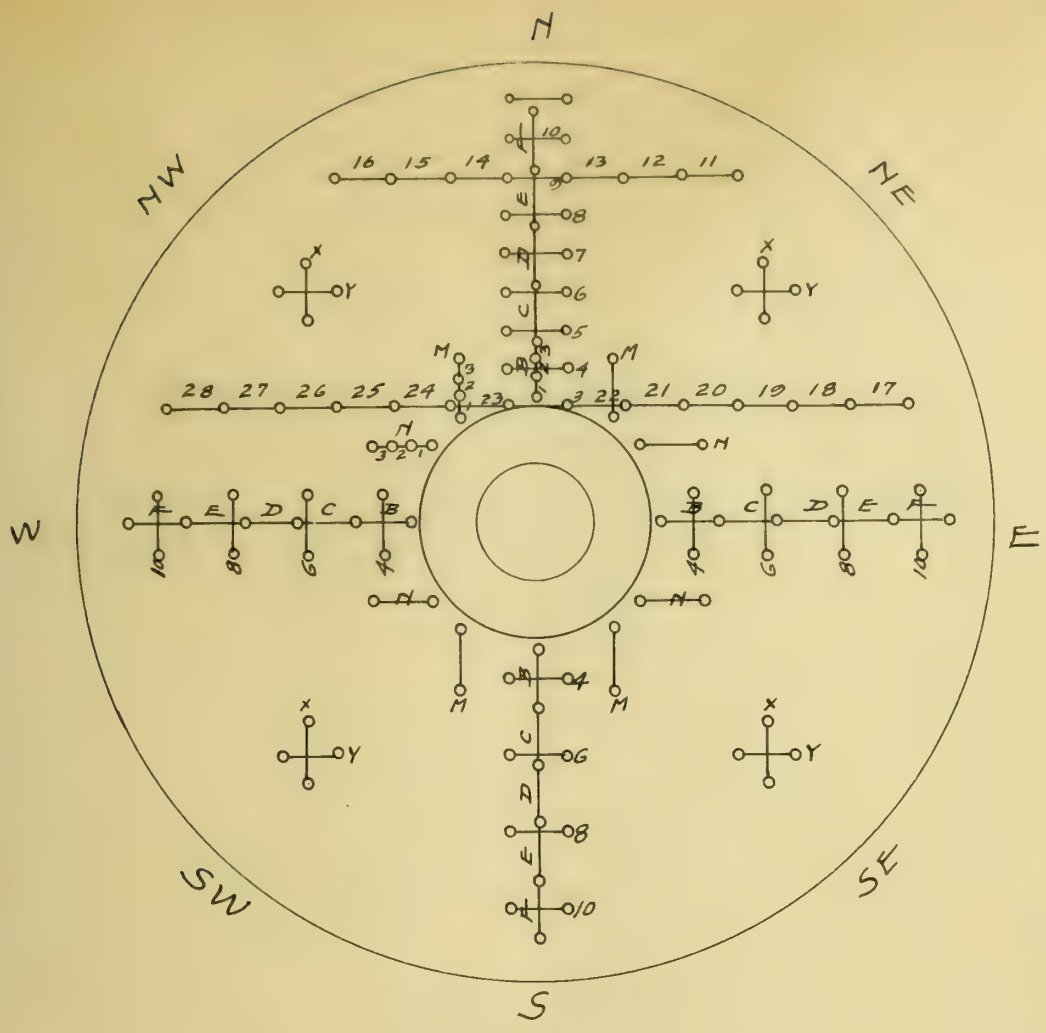
[This should be about .9(7-2) inches = (7-2 inches)]



...age Lines in the Steel. Slab 1251.

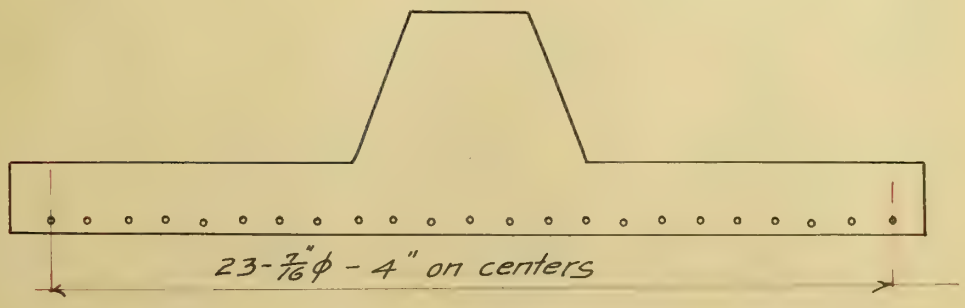
Figure 14.

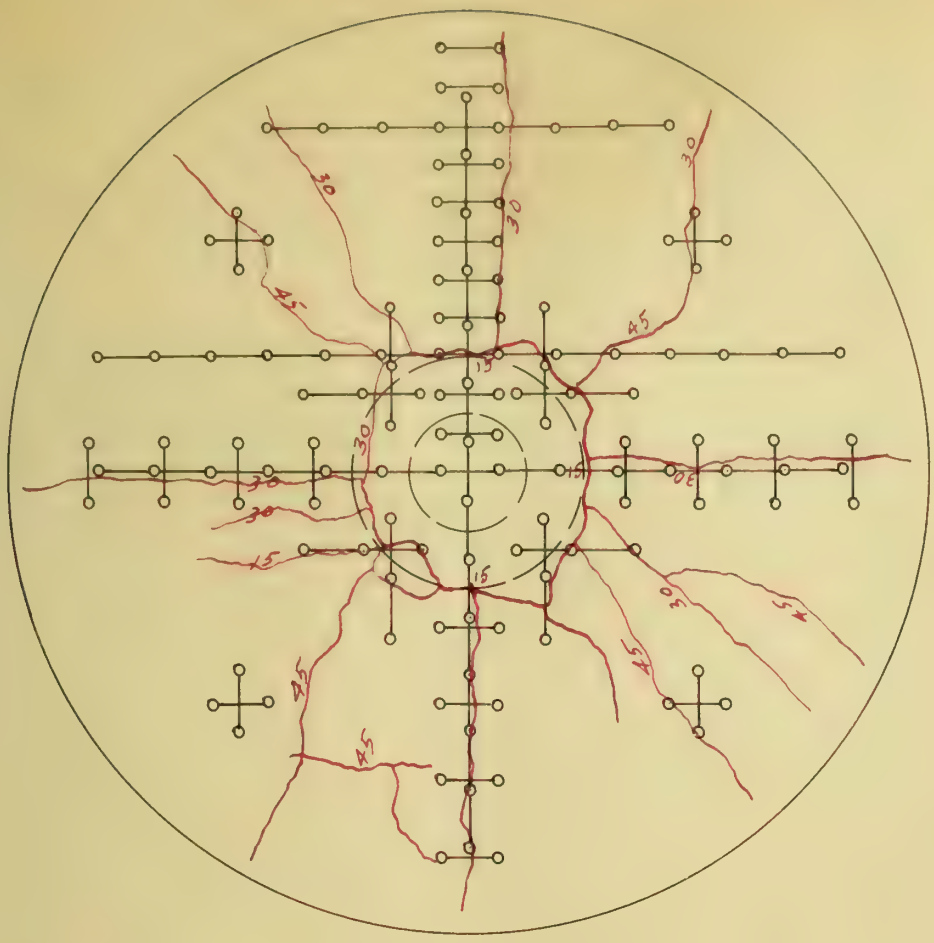




Cage Lines in the Concrete. Slab 1251.

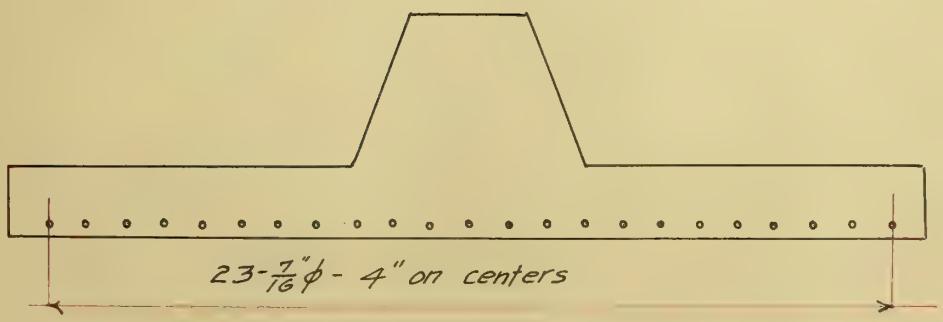
Figure 15.





Sketch of Cracks. Slab 1251.

Figure 16.

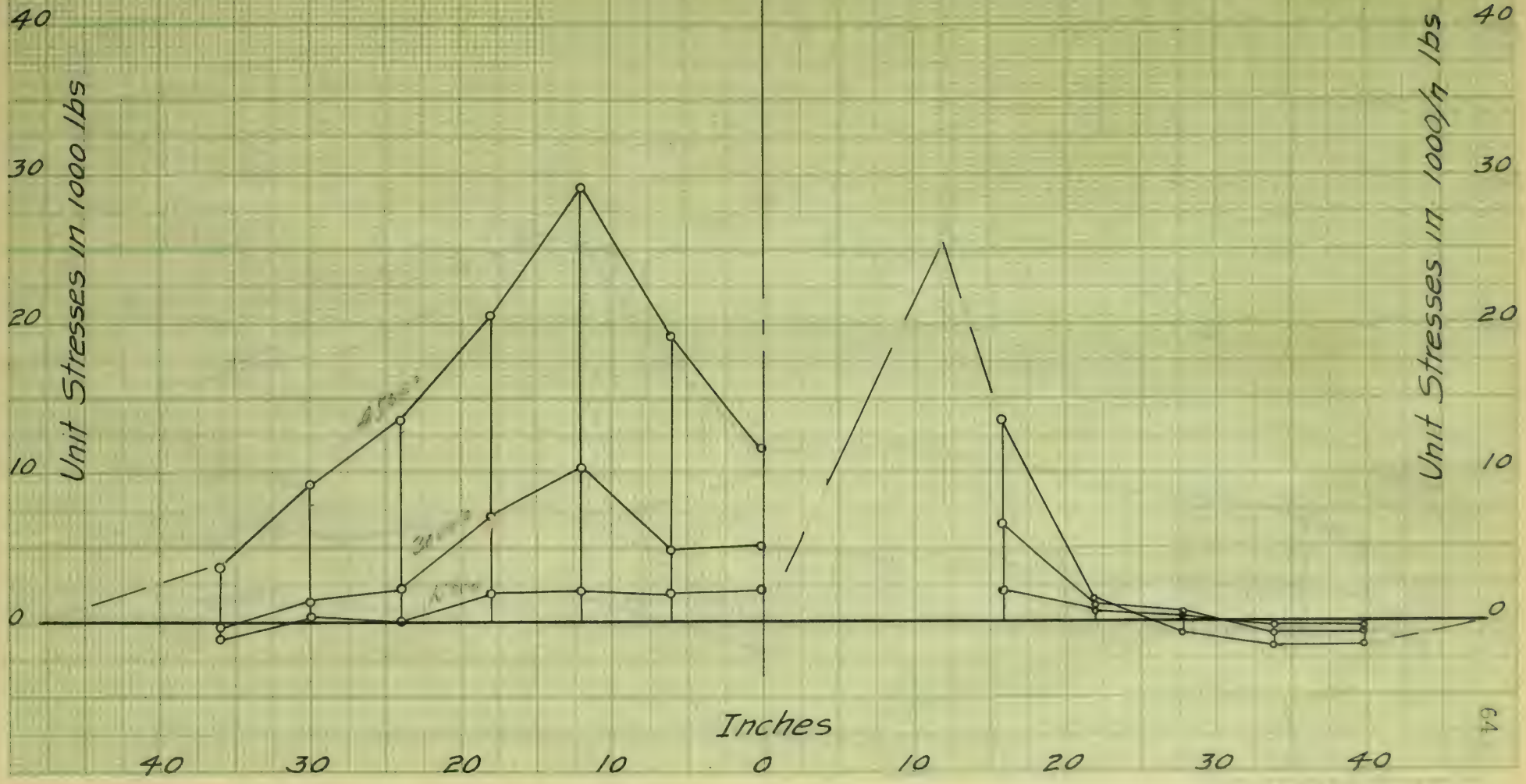


Slab 1251

Average Radial Stresses

Steel

Concrete



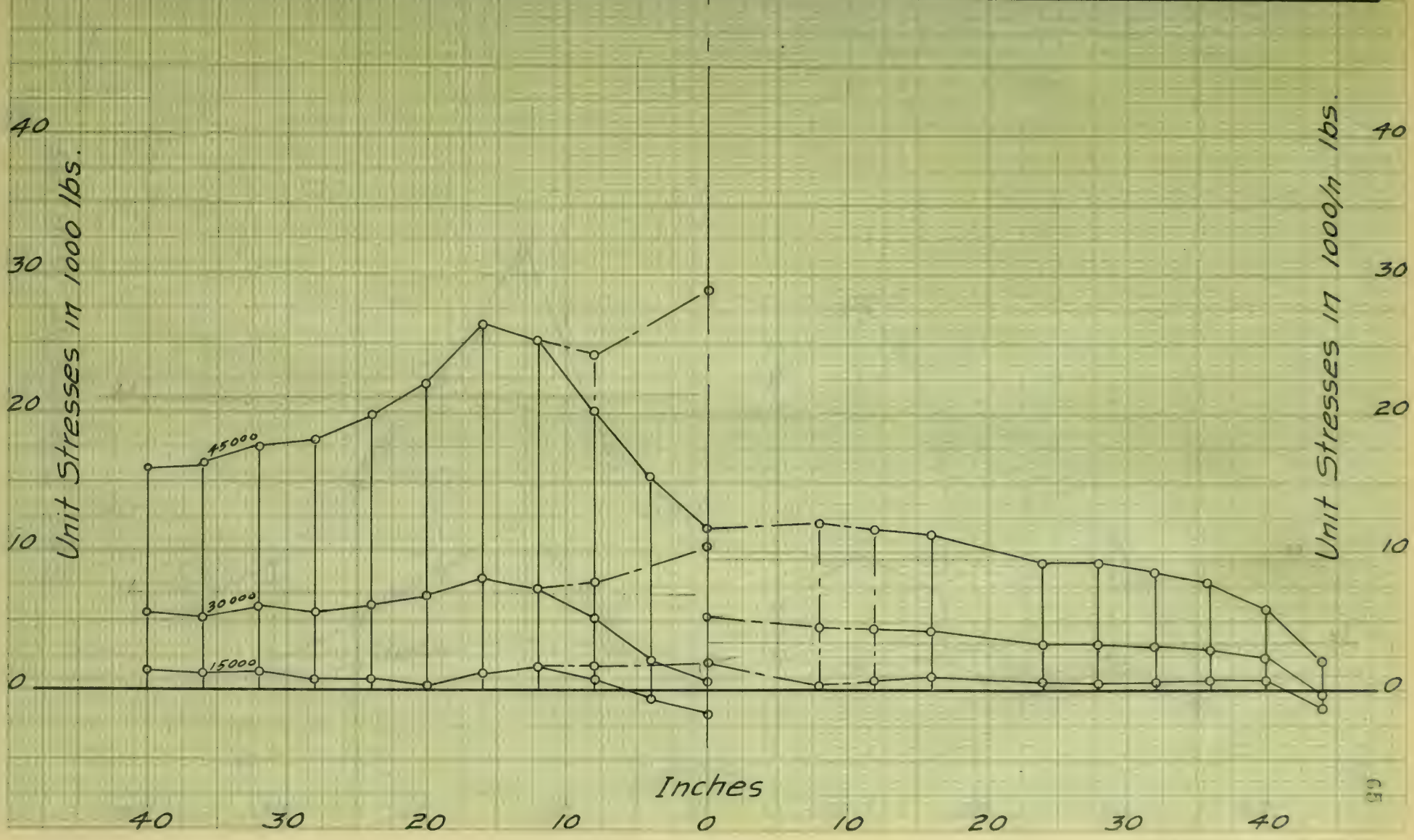
64

Slab 1251

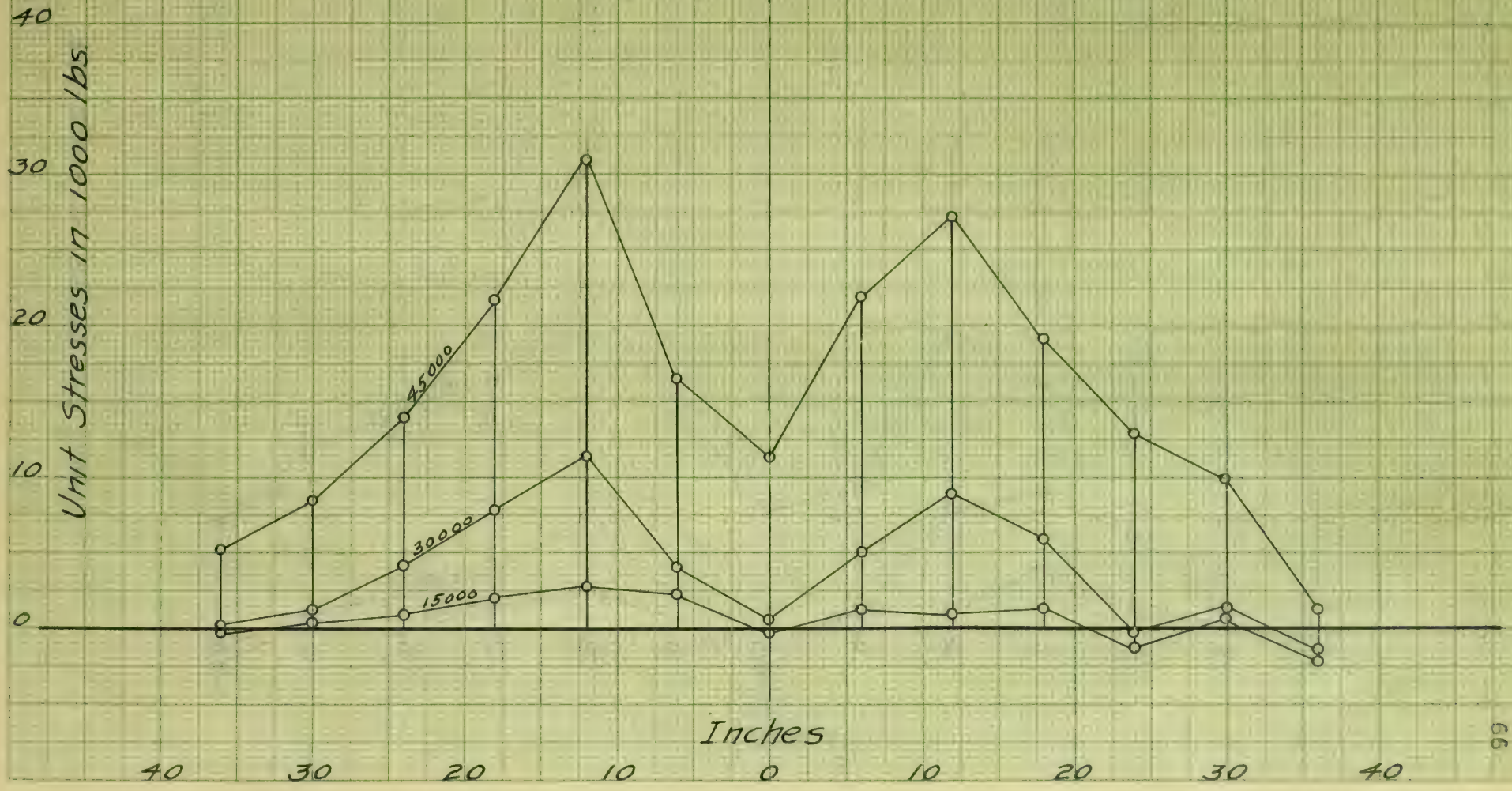
Average Circumferential Stresses

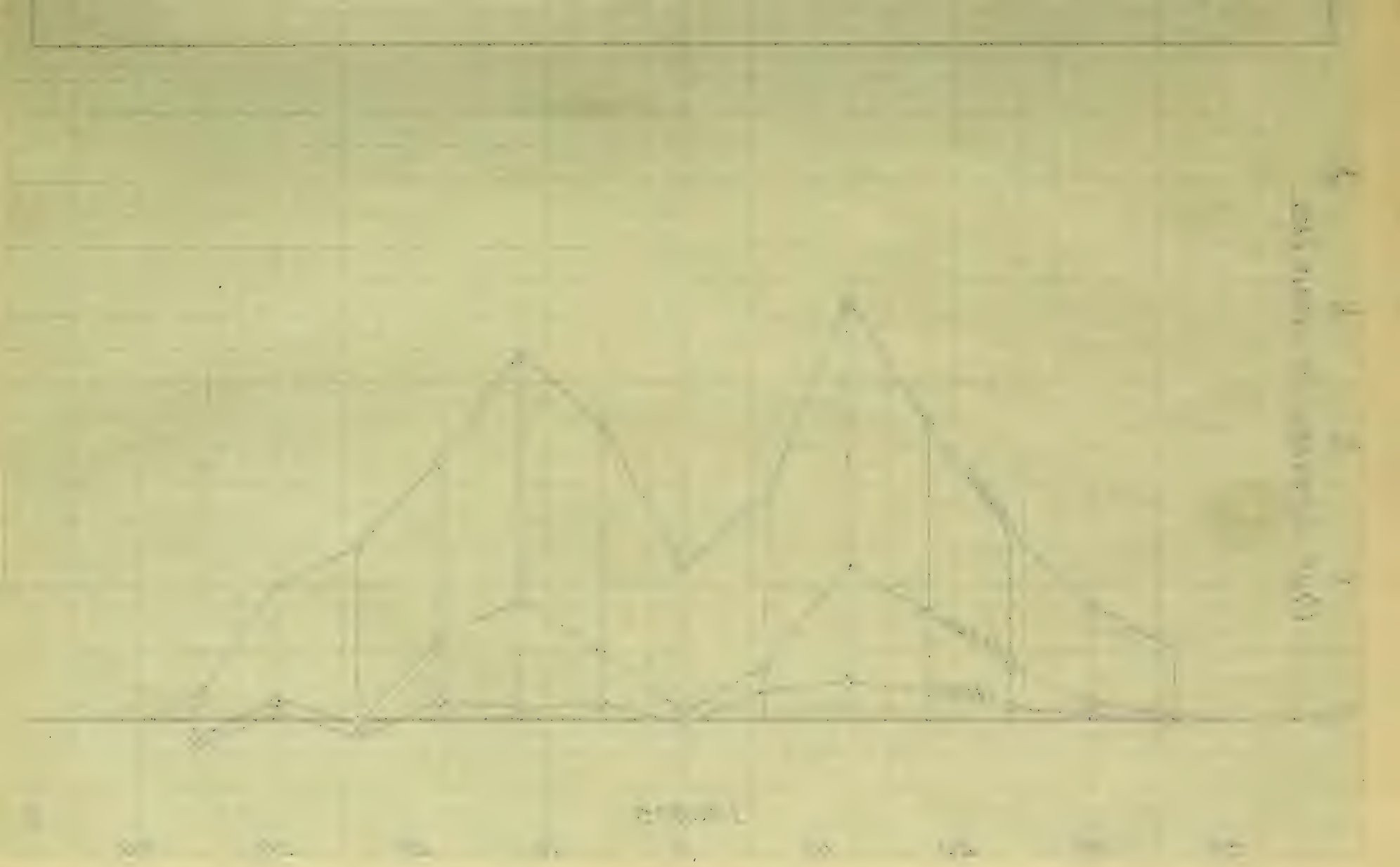
Steel

Concrete

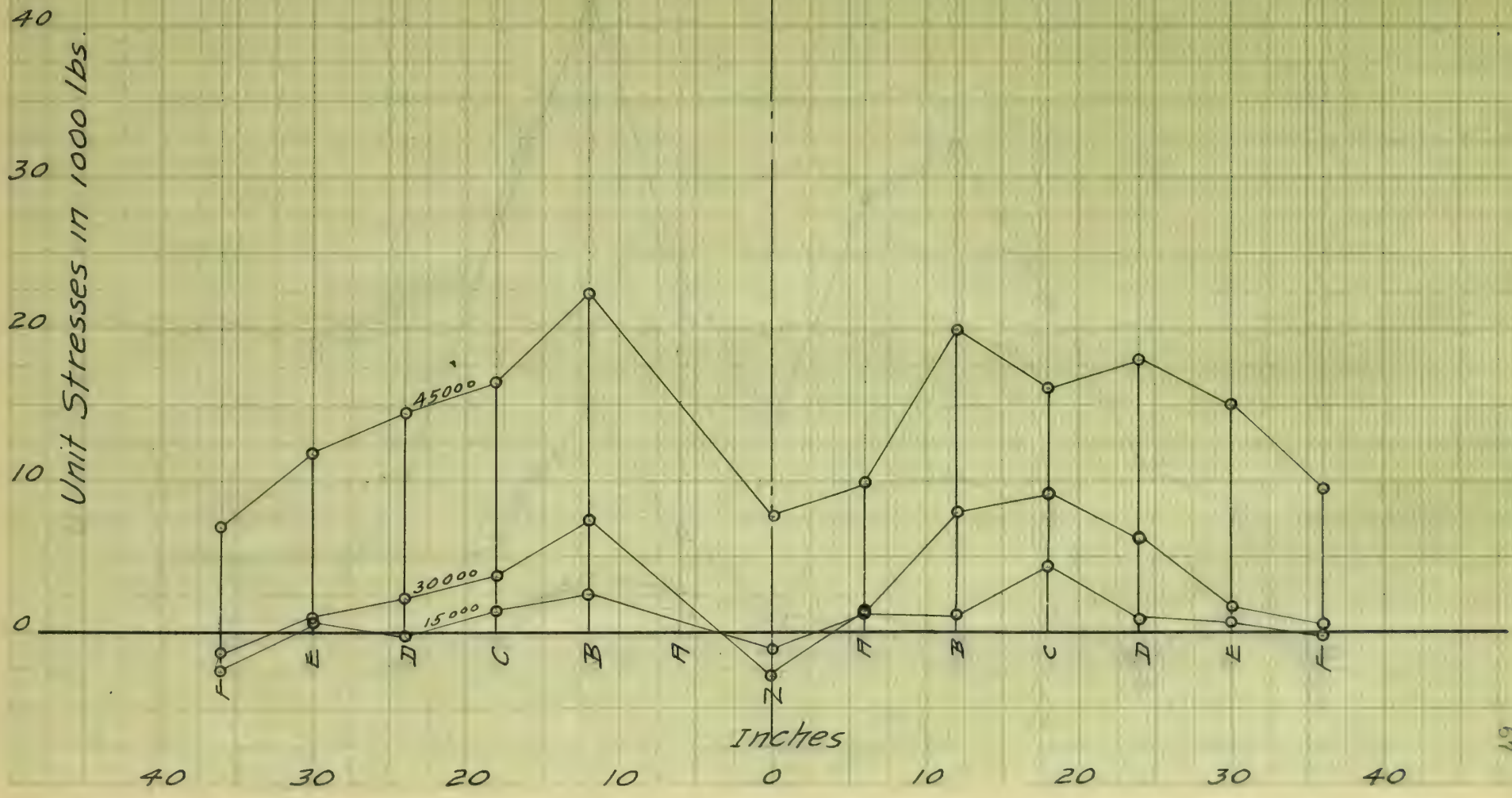


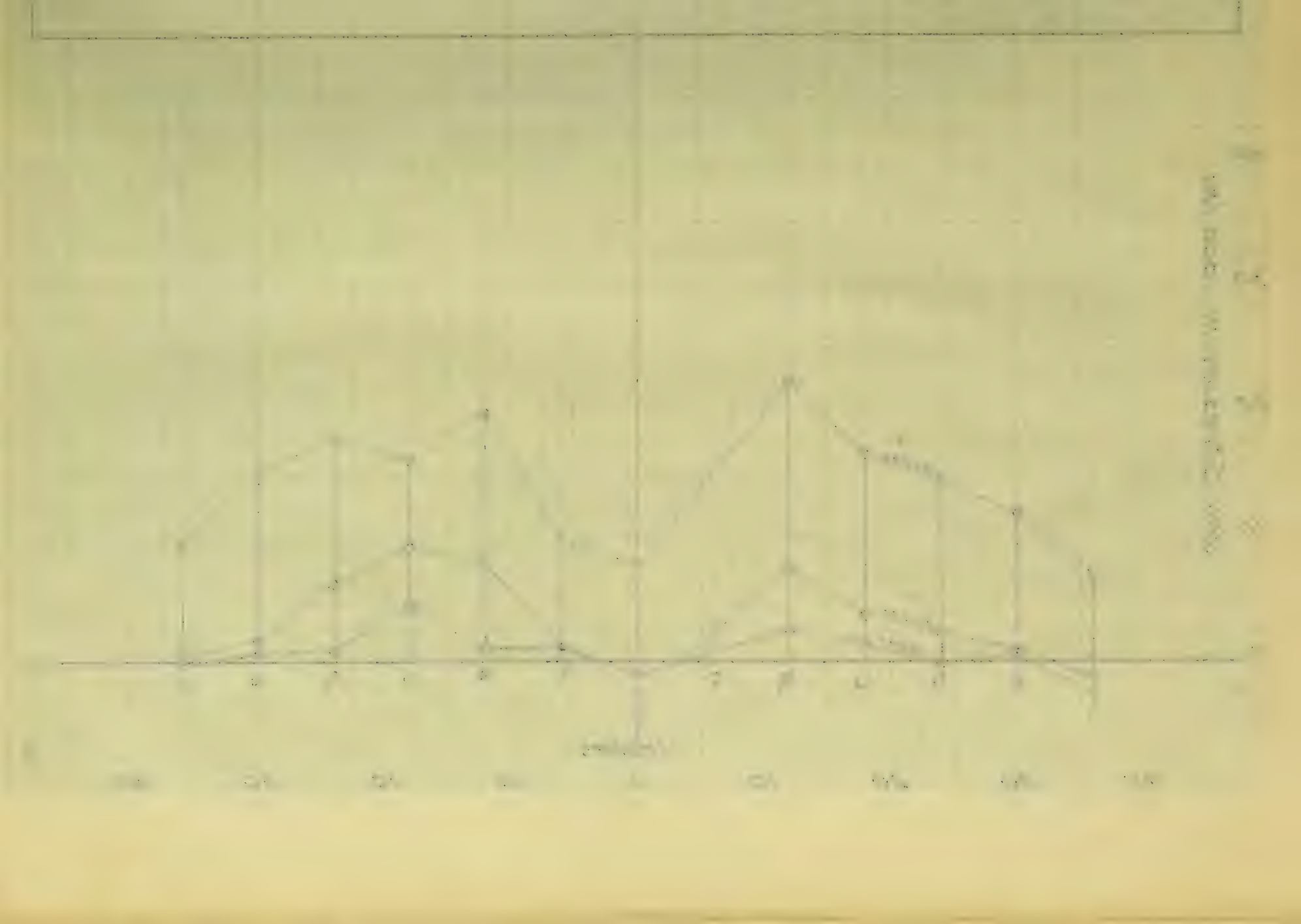
Average Radial Stresses in Steel



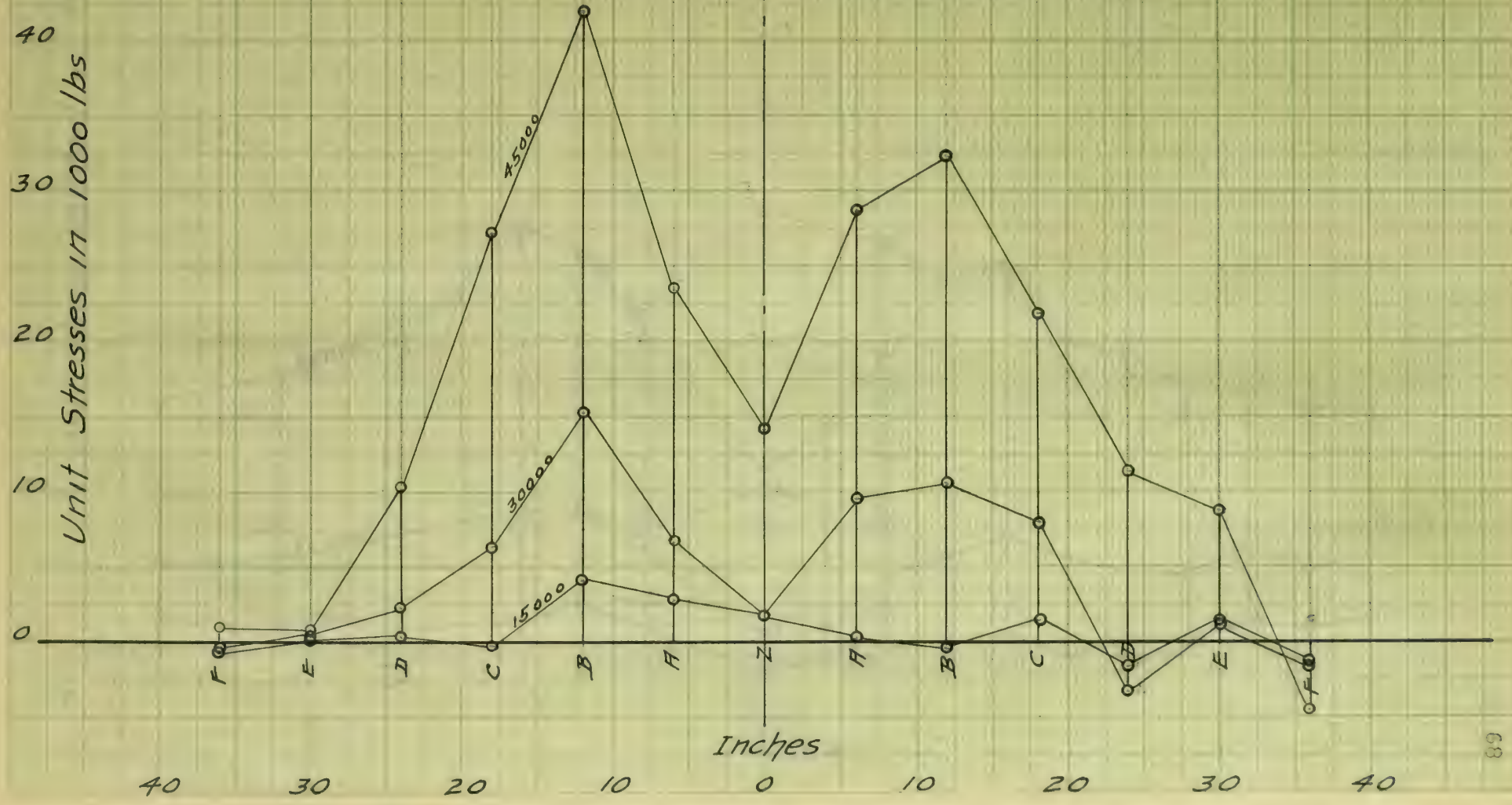


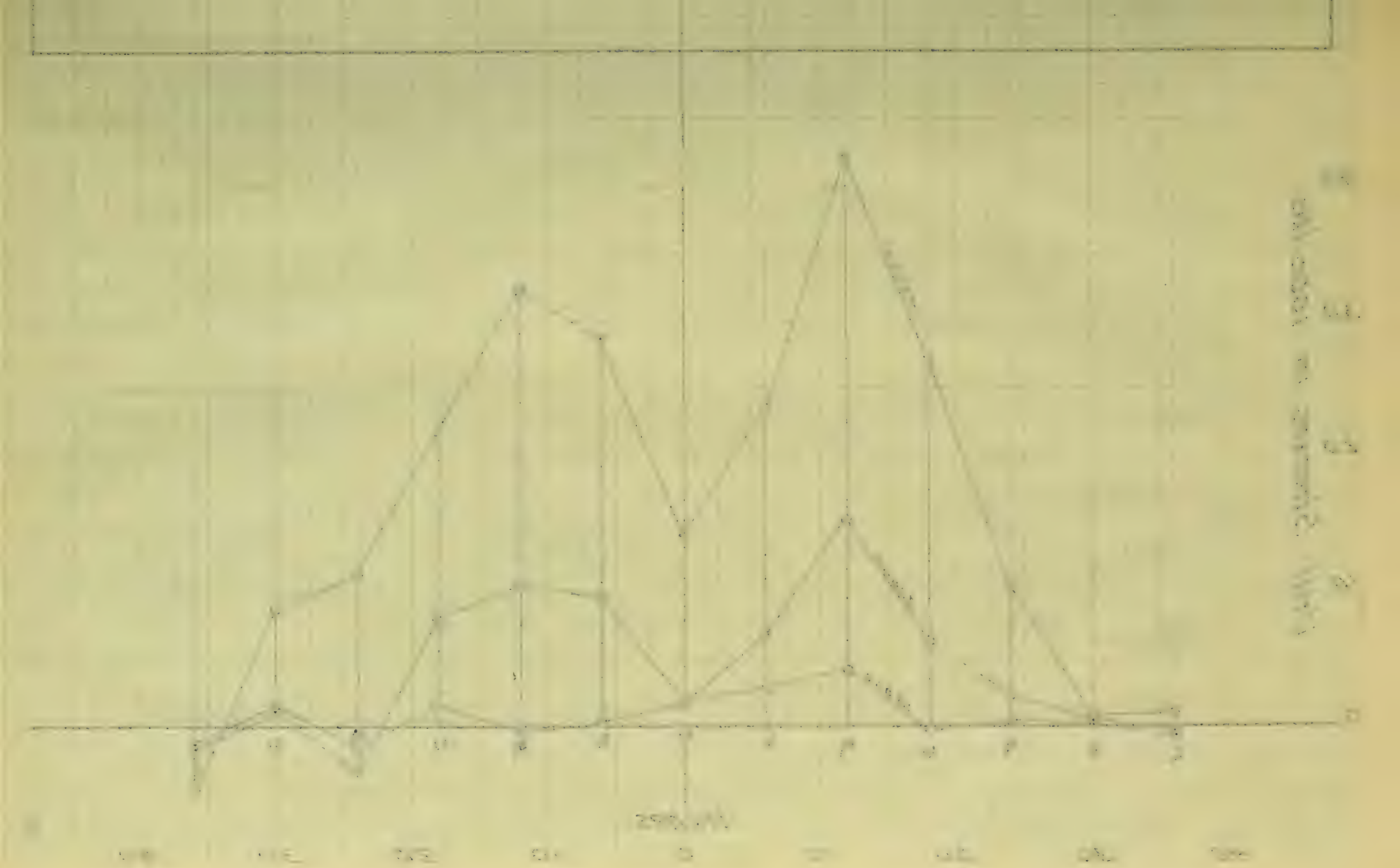
Radial Stresses in Steel





Radial Stresses in Steel



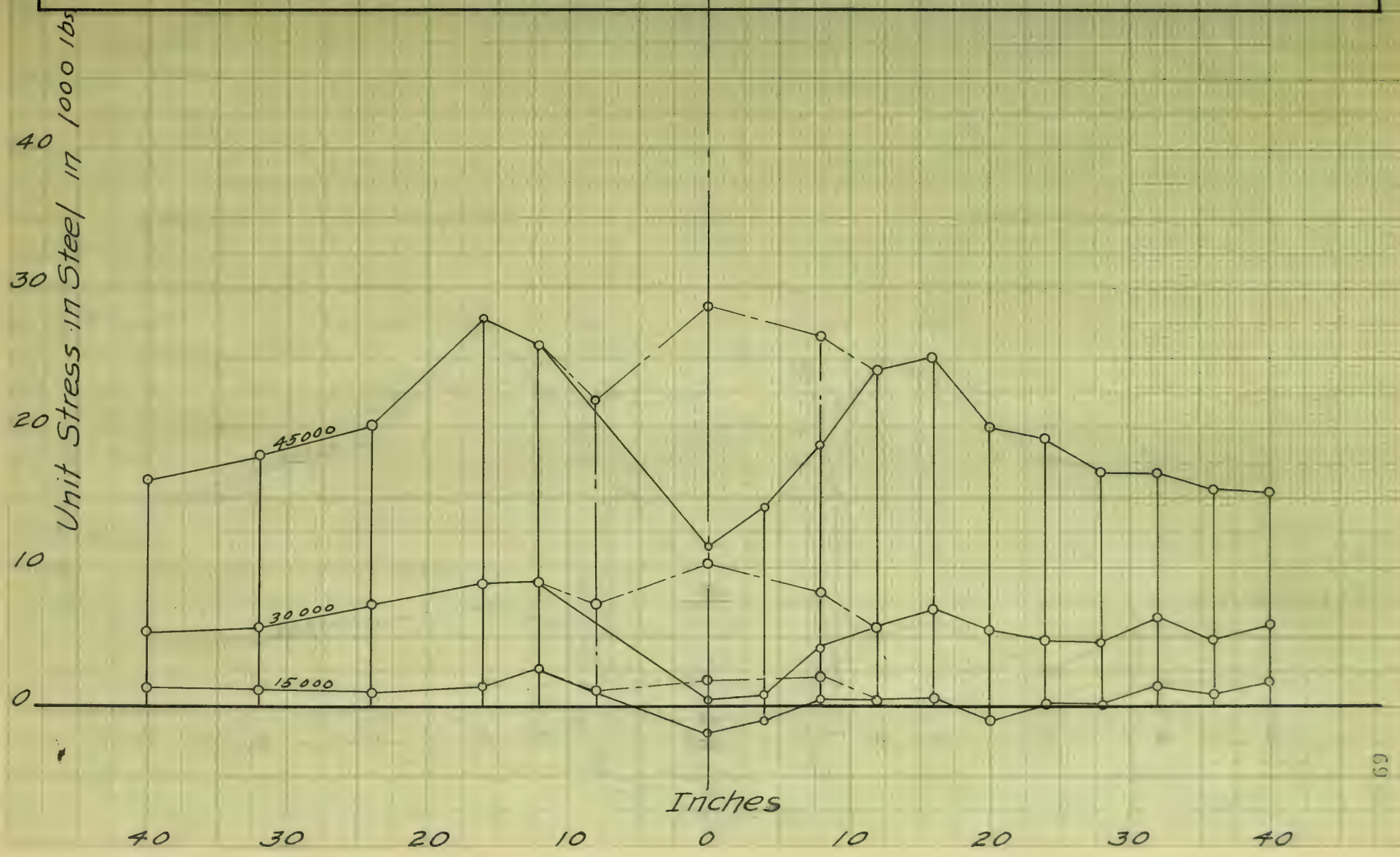


SW

S100-1231

NE

Average Circumferential Stresses in Steel



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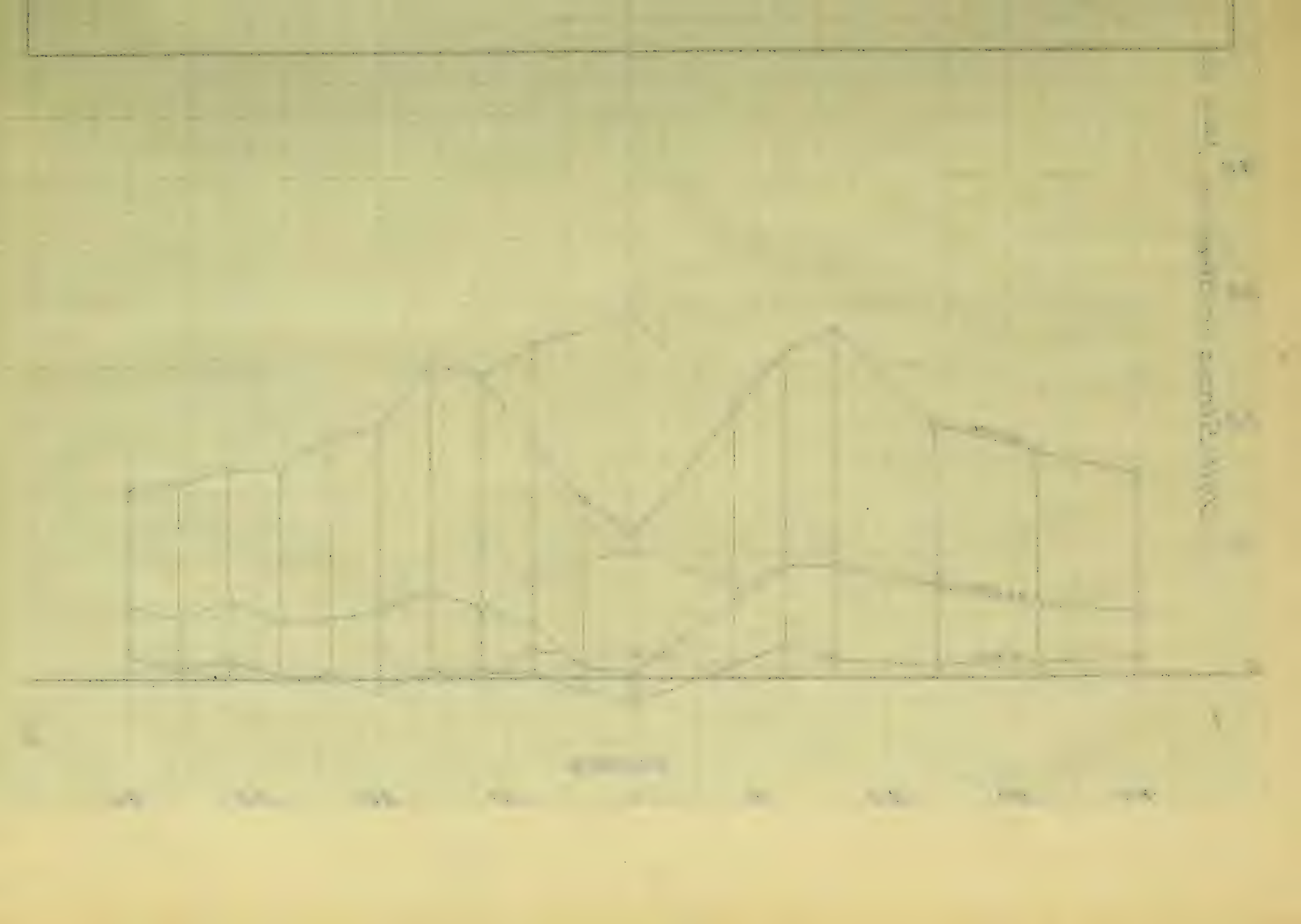
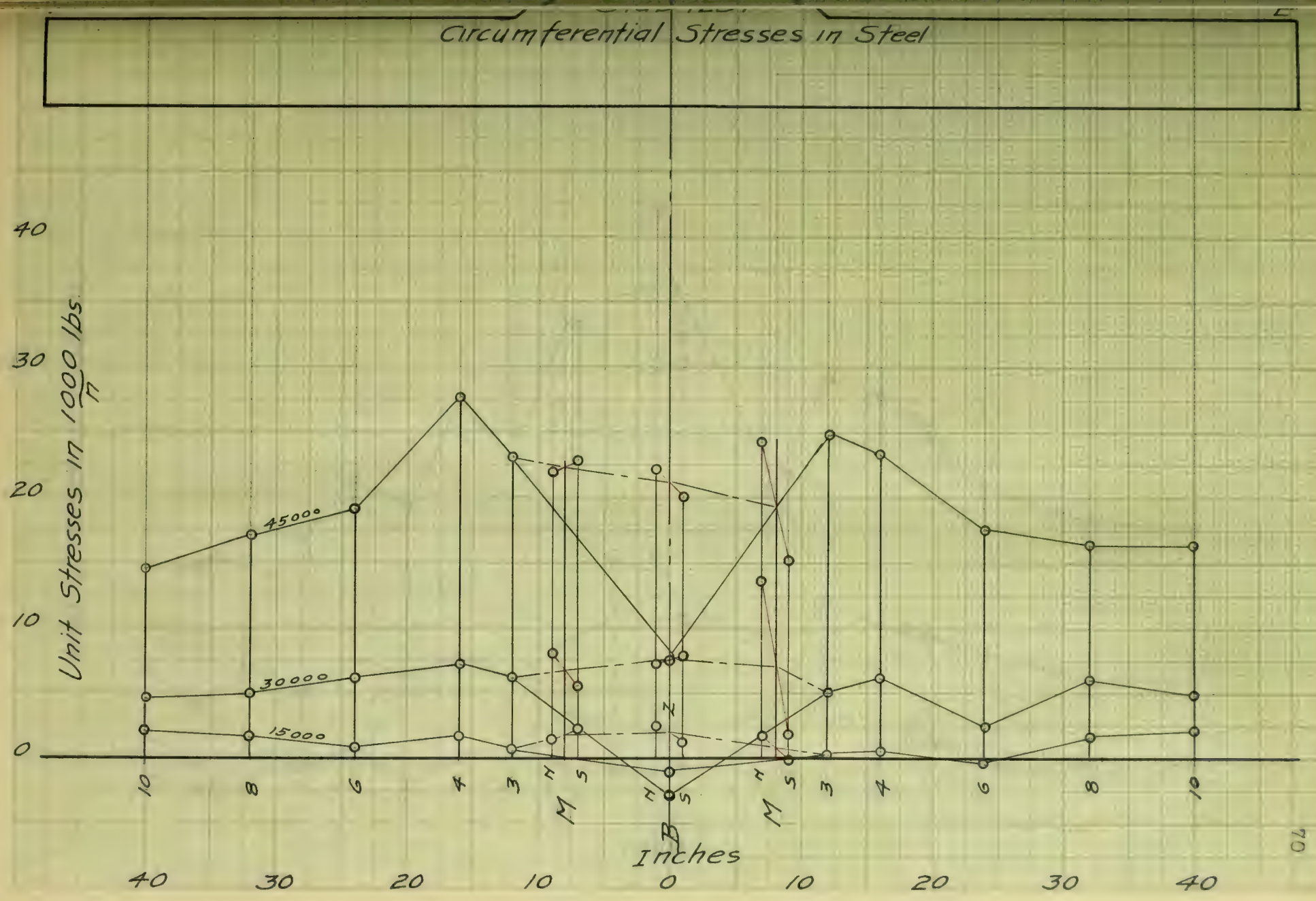
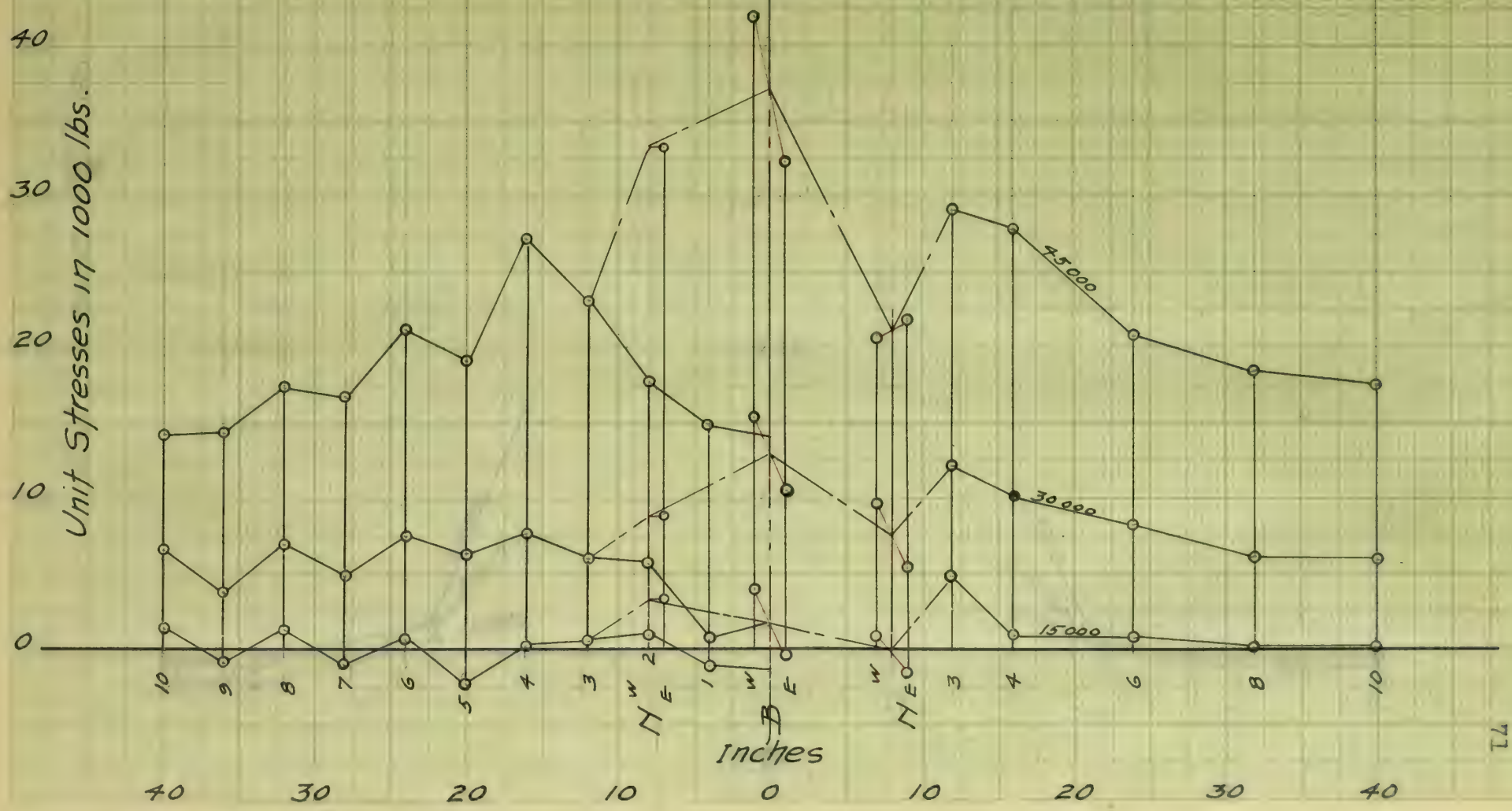
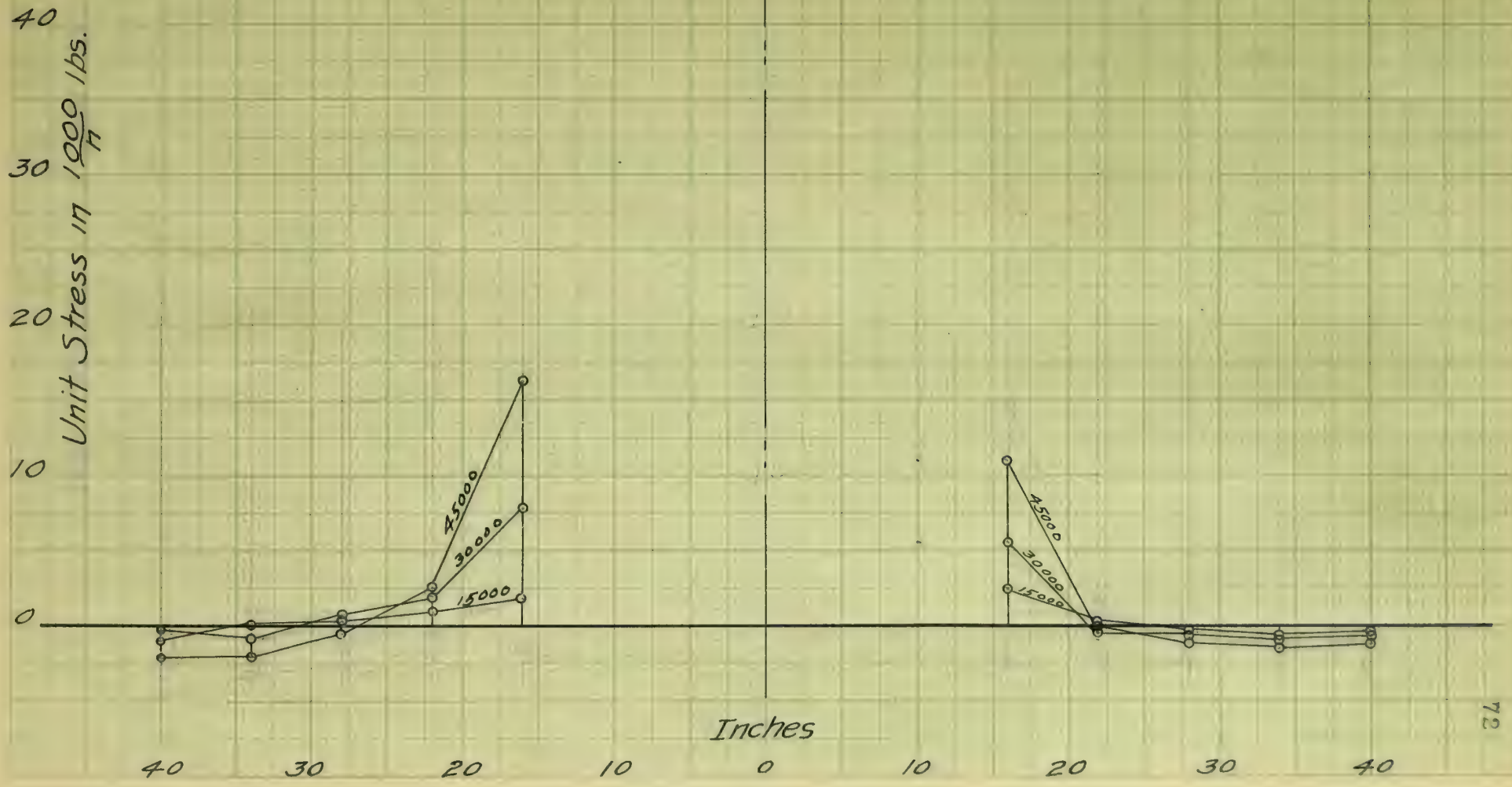


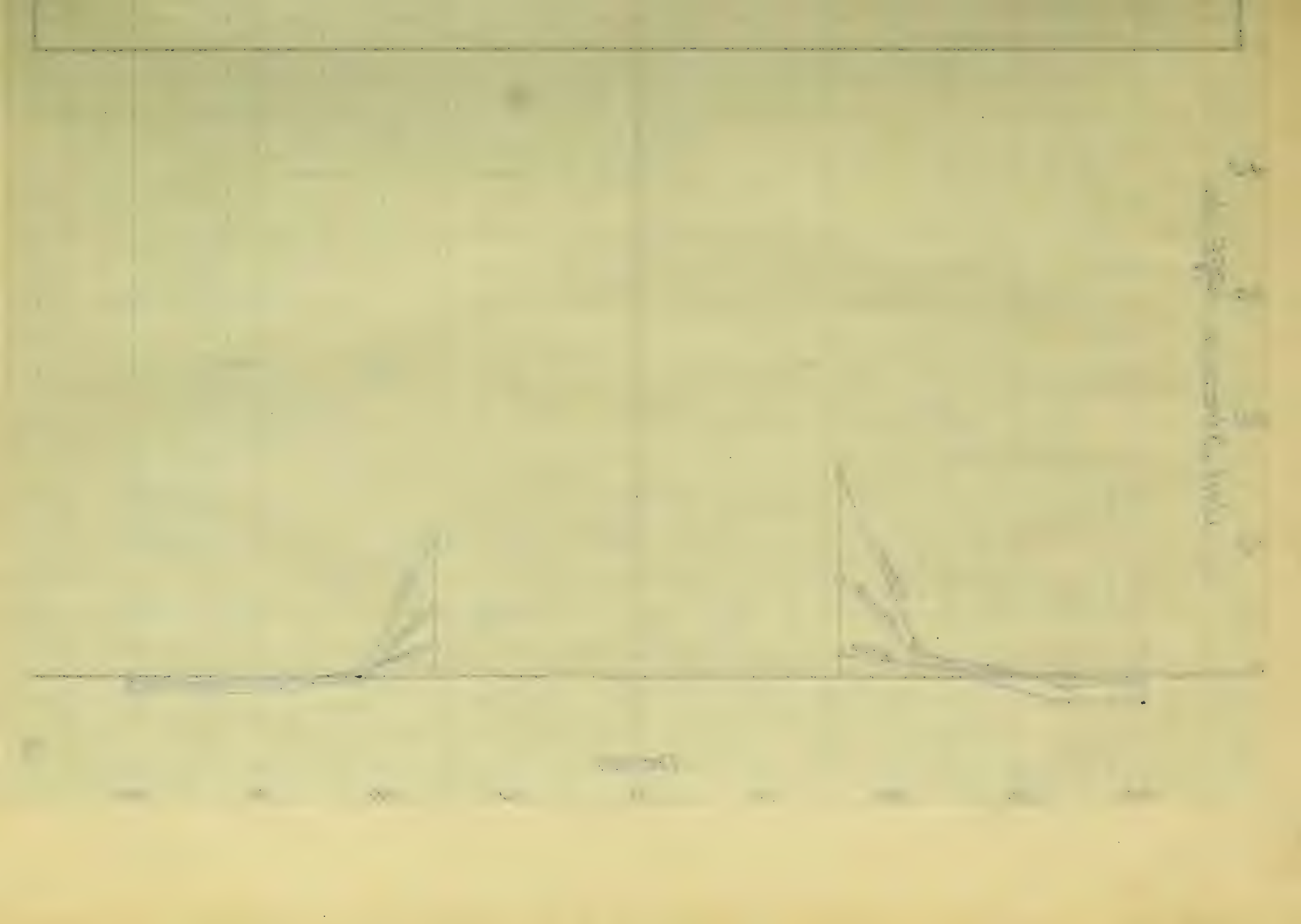

Circumferential Stresses in Steel
40
30
20
10
0
Unit Stresses in 1000 lbs.
45000
30000
15000
10
8
6
4
3
M
S
N
Z
B
Inches
40
30
20
10
0
10
20
30
40

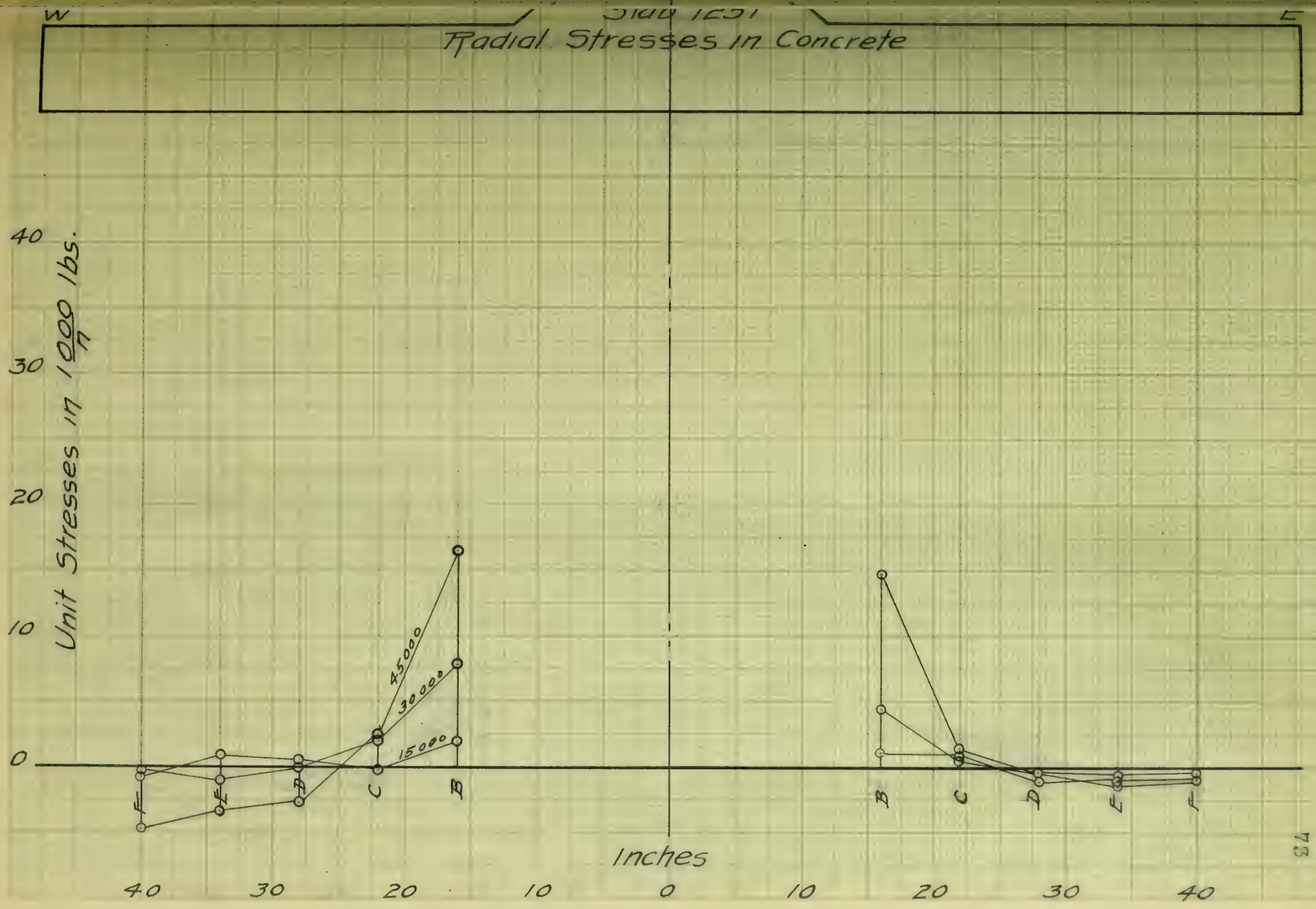
Circumferential Stresses in Steel



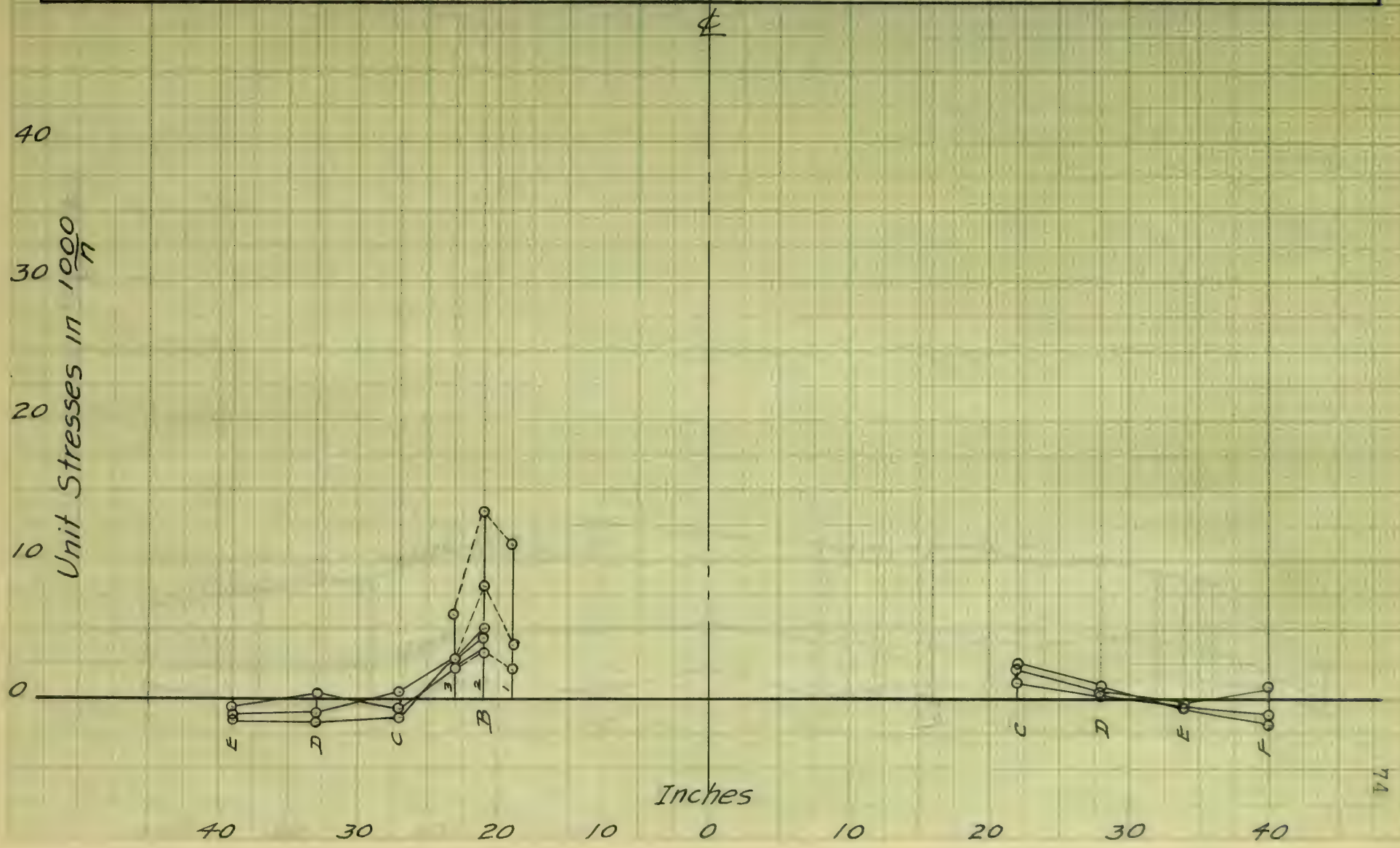
Average Radial Stresses in Concrete

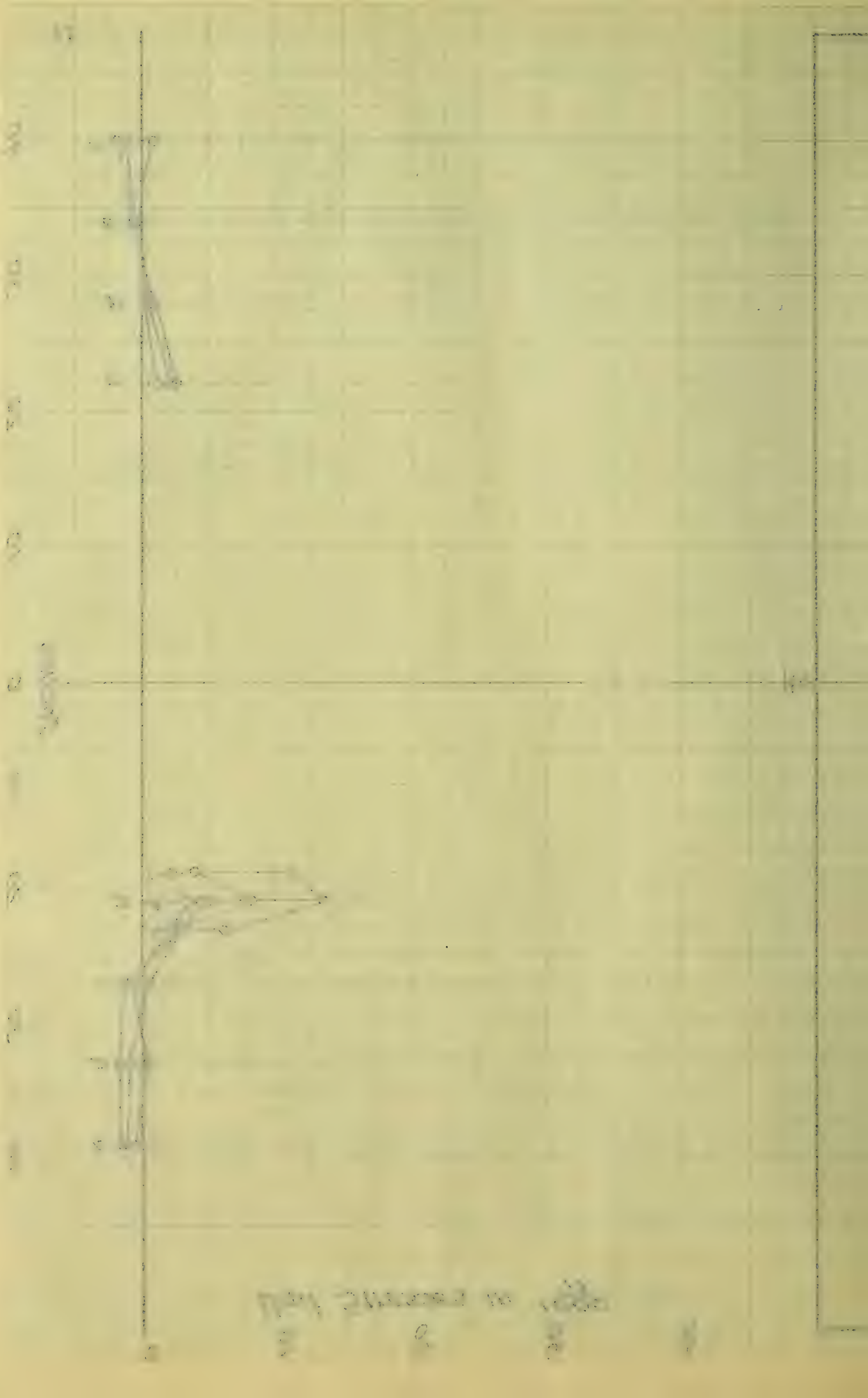




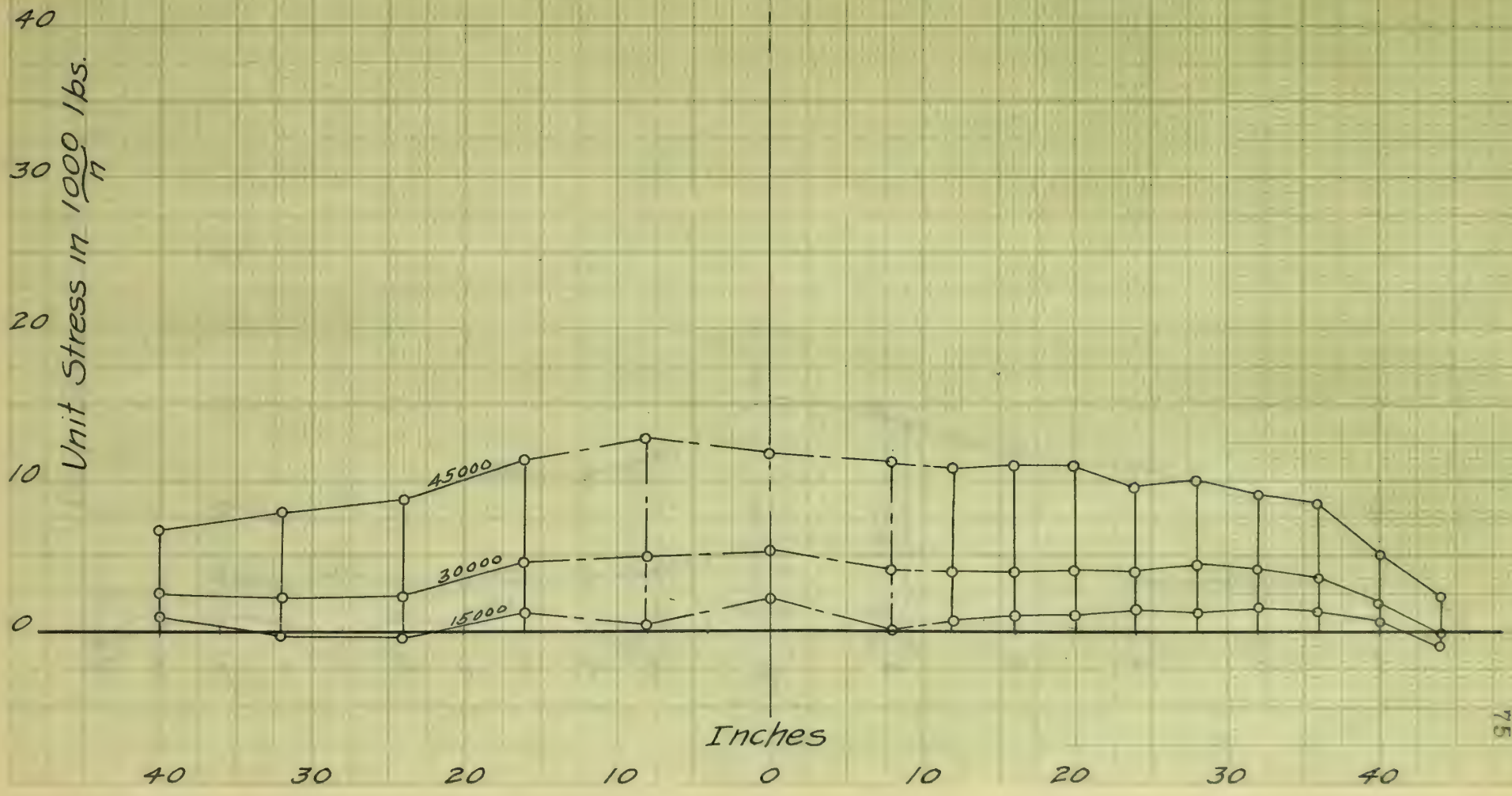

W
Slab 1231
E
Radial Stresses in Concrete
40
30
20
10
0
Unit Stresses in 1000 lbs.
45000
30000
15000
F
E
D
C
B
B
C
D
E
F
Inches
40
30
20
10
0
10
20
30
40
73

Radial Stresses in Concrete





Average Circumferential Stresses in Concrete



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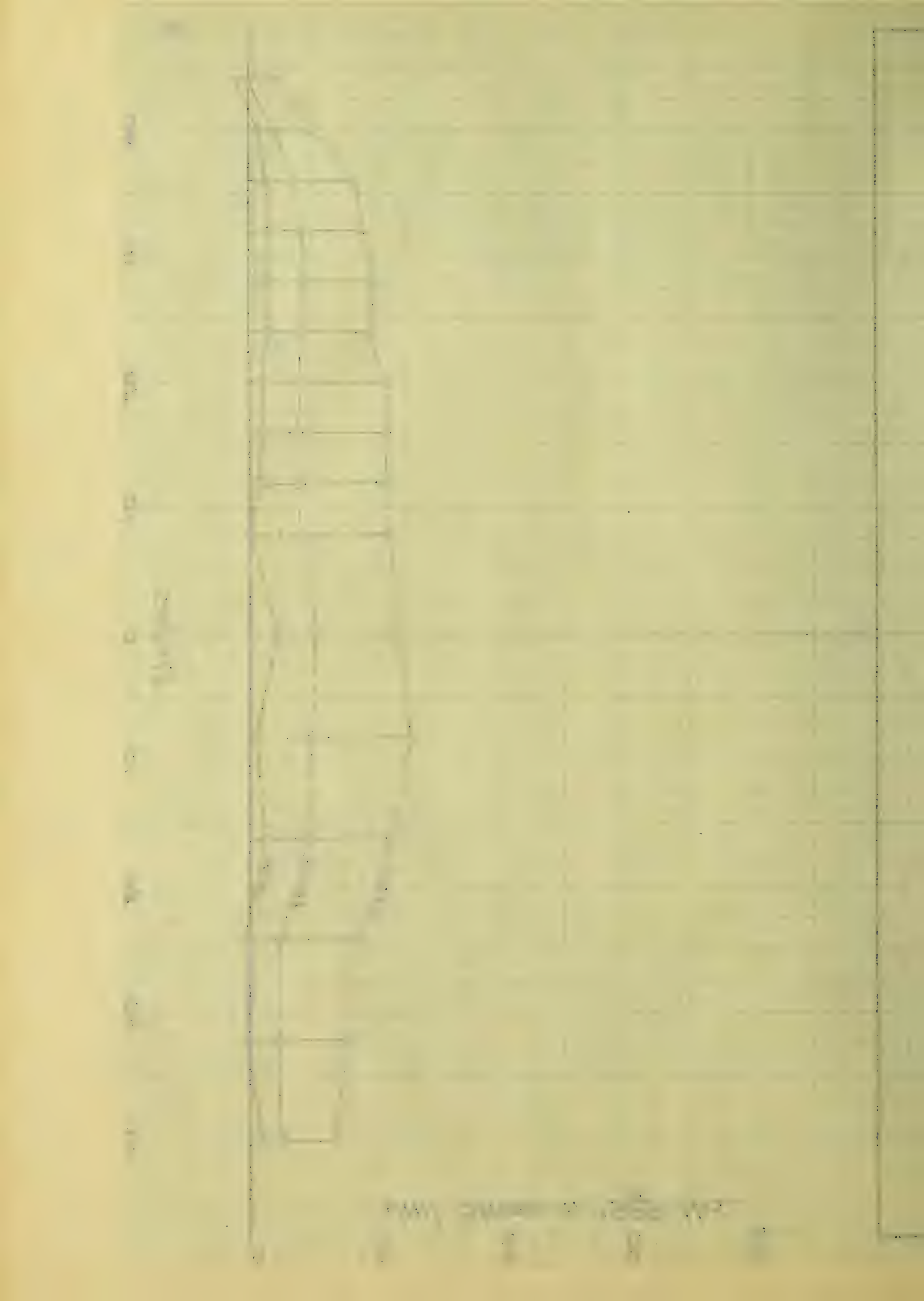
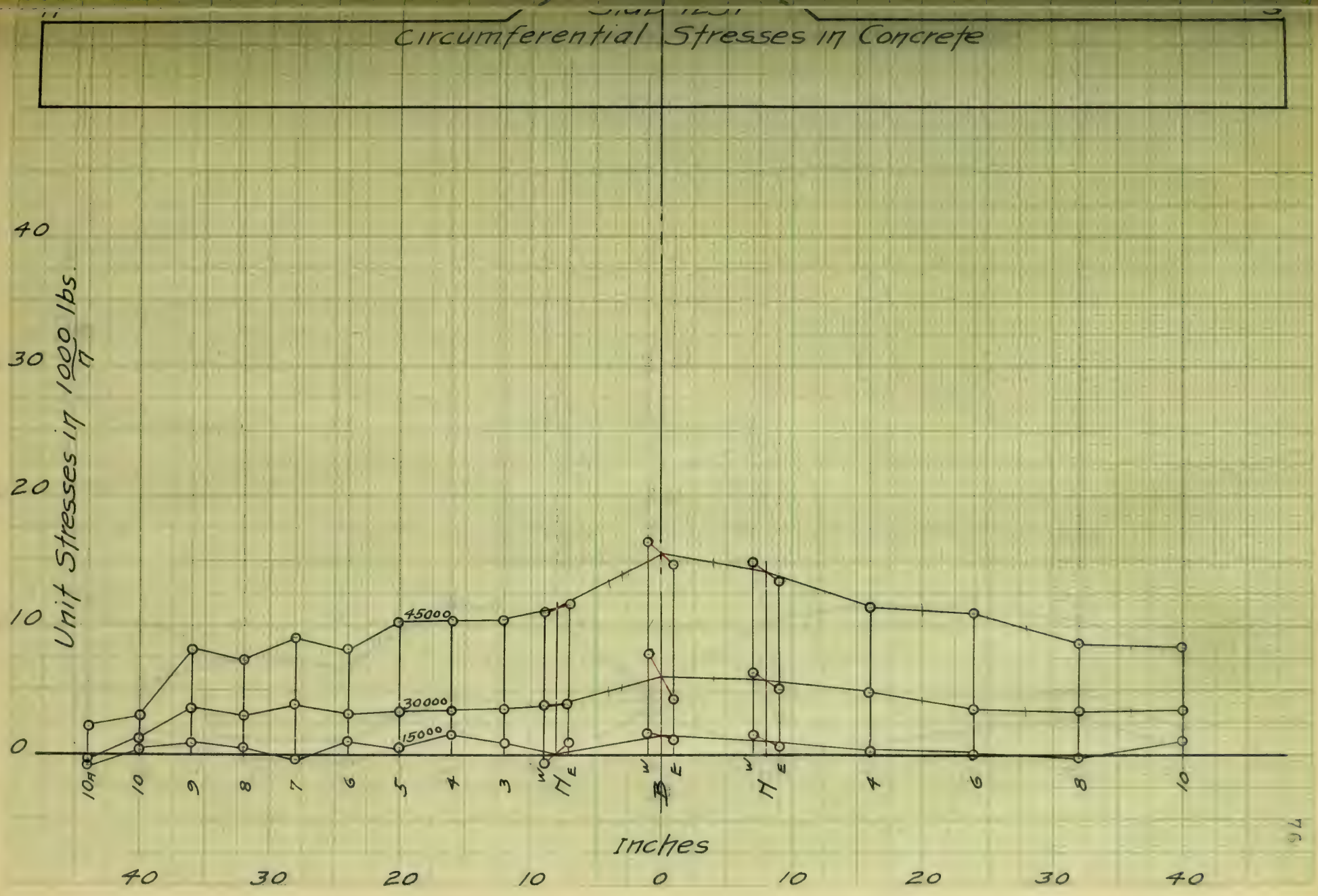
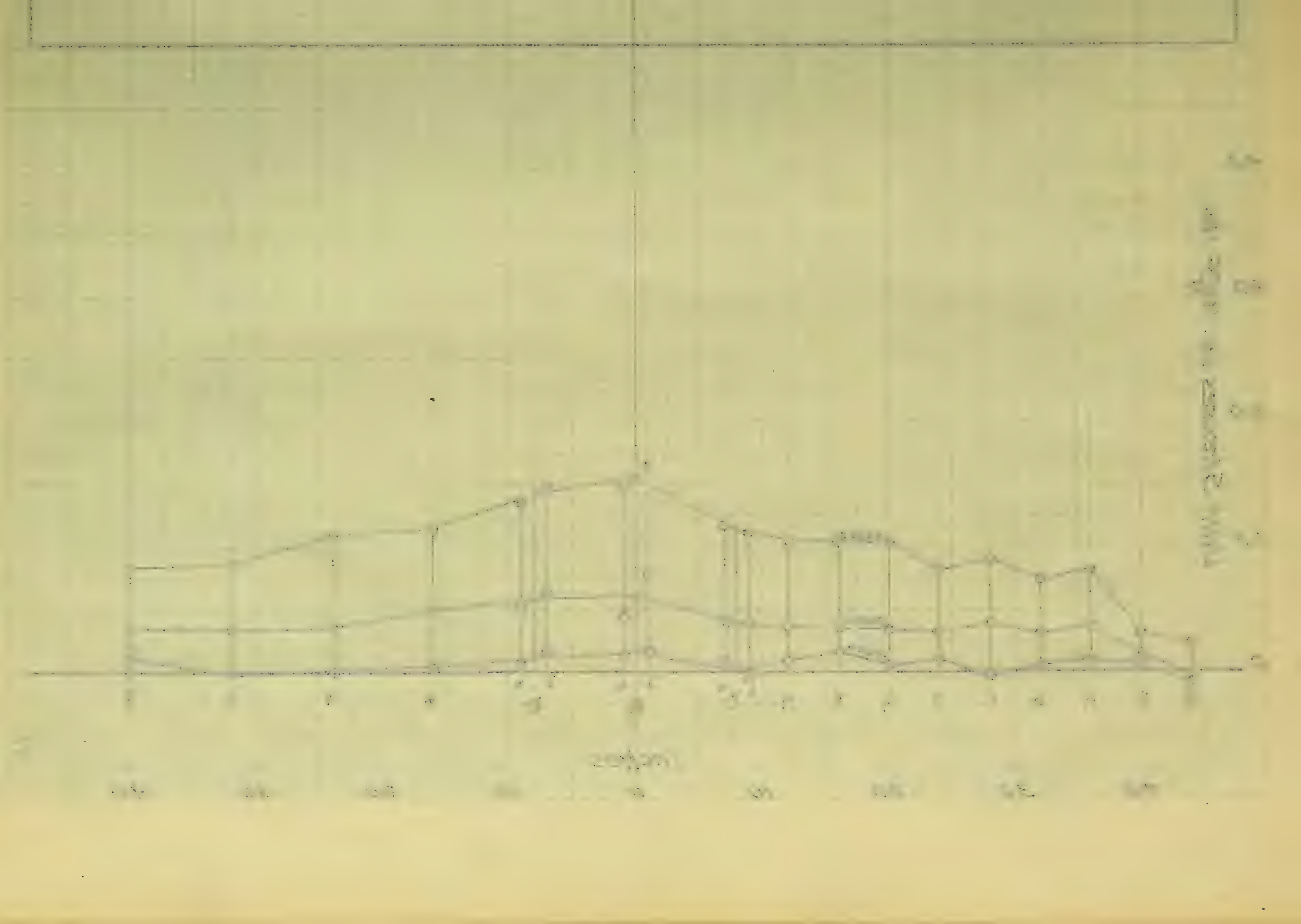
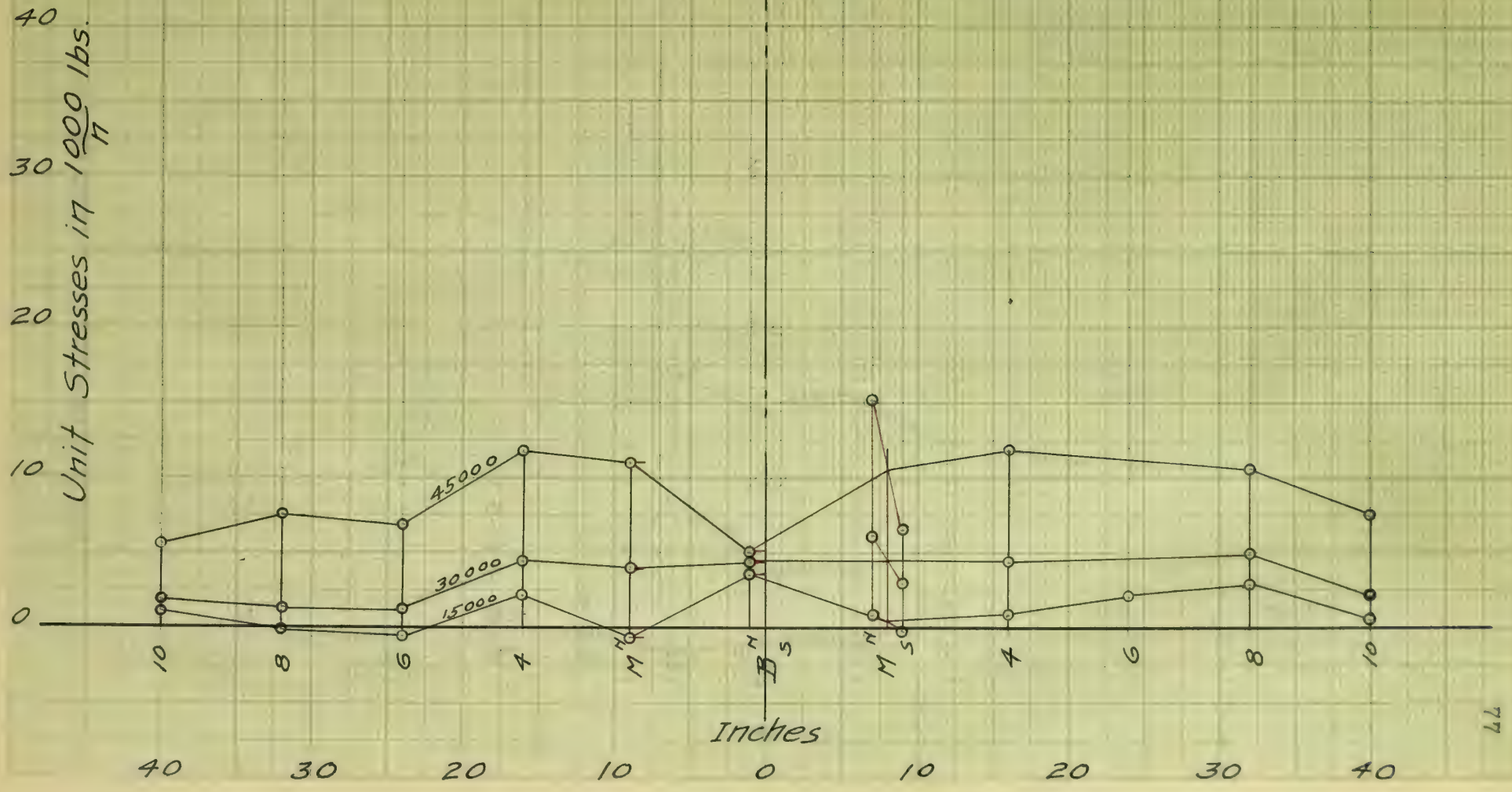


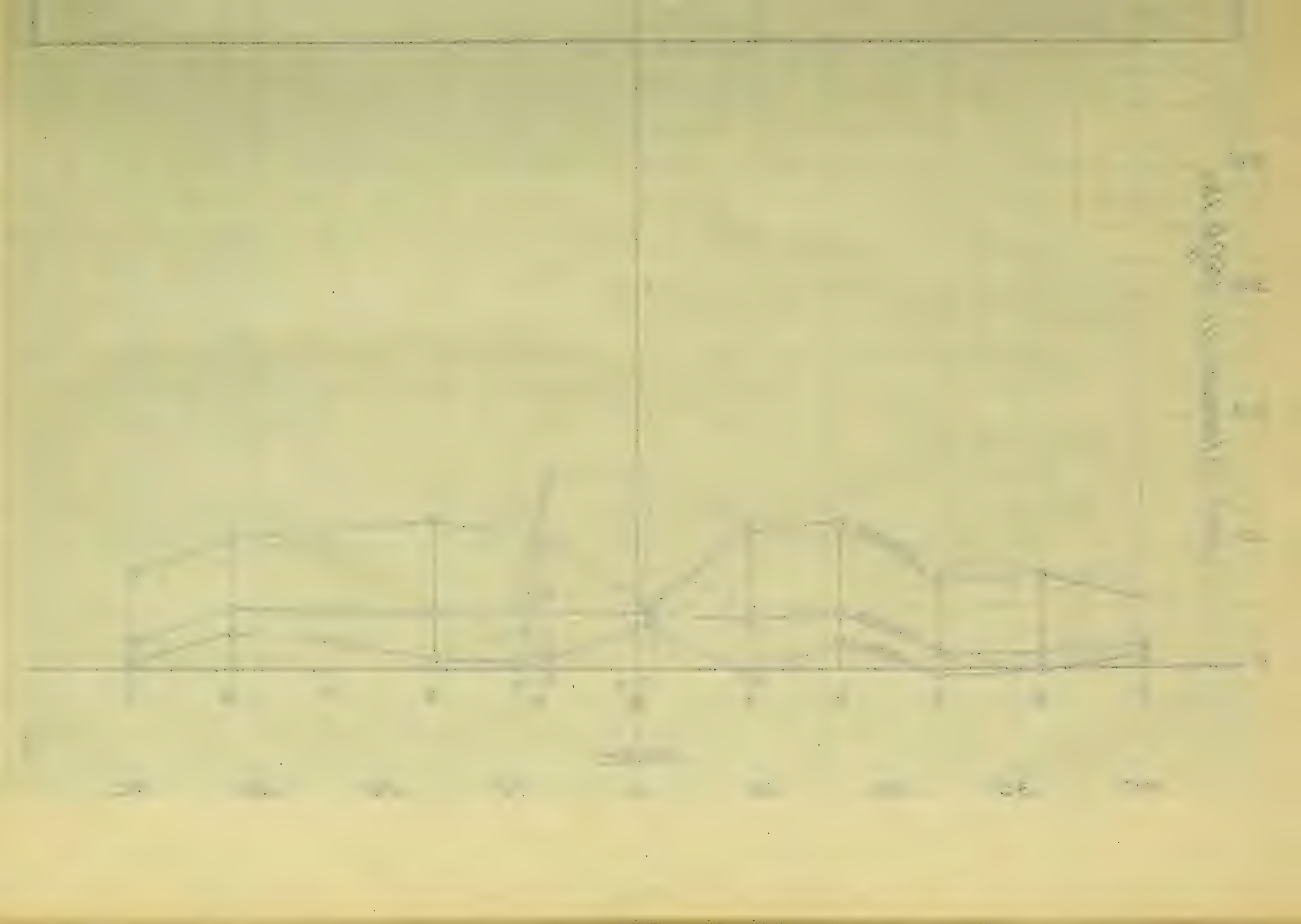
Circumferential Stresses in Concrete





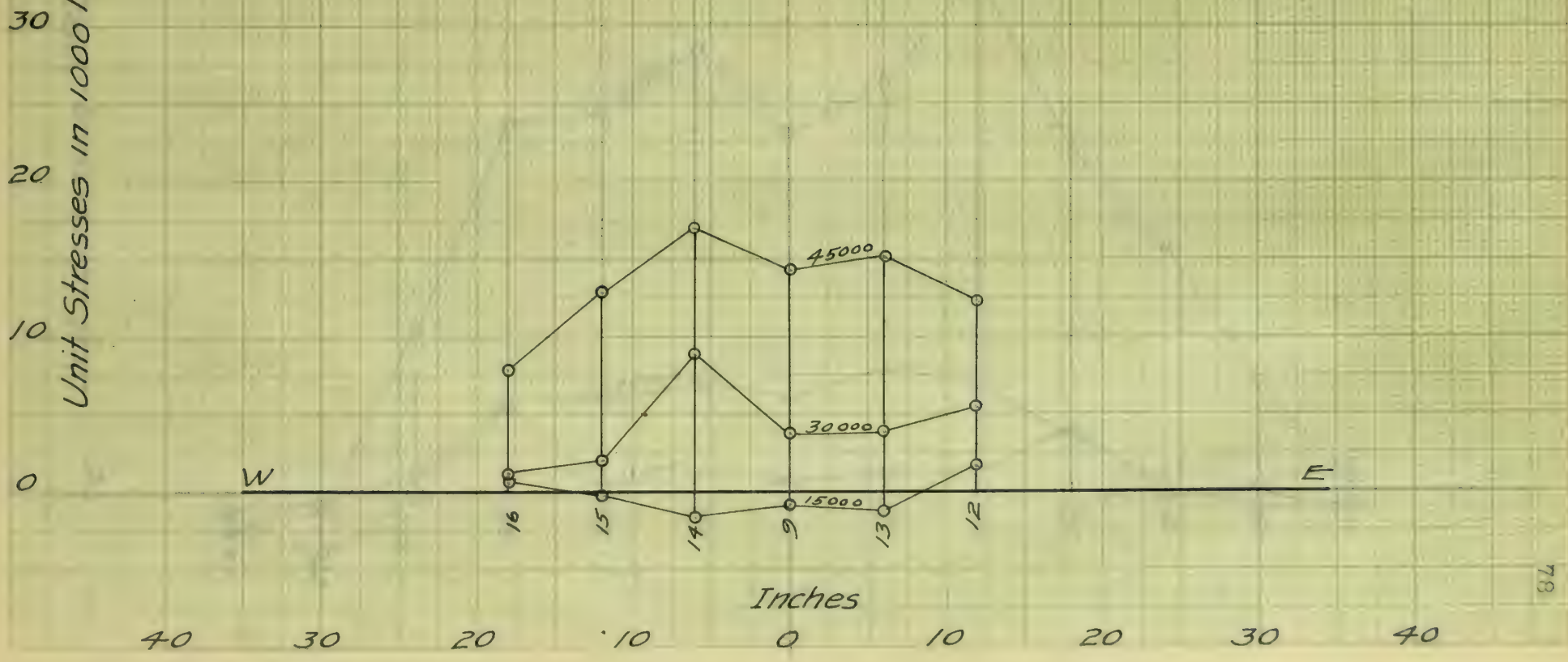
Circumferential Stresses in Concrete





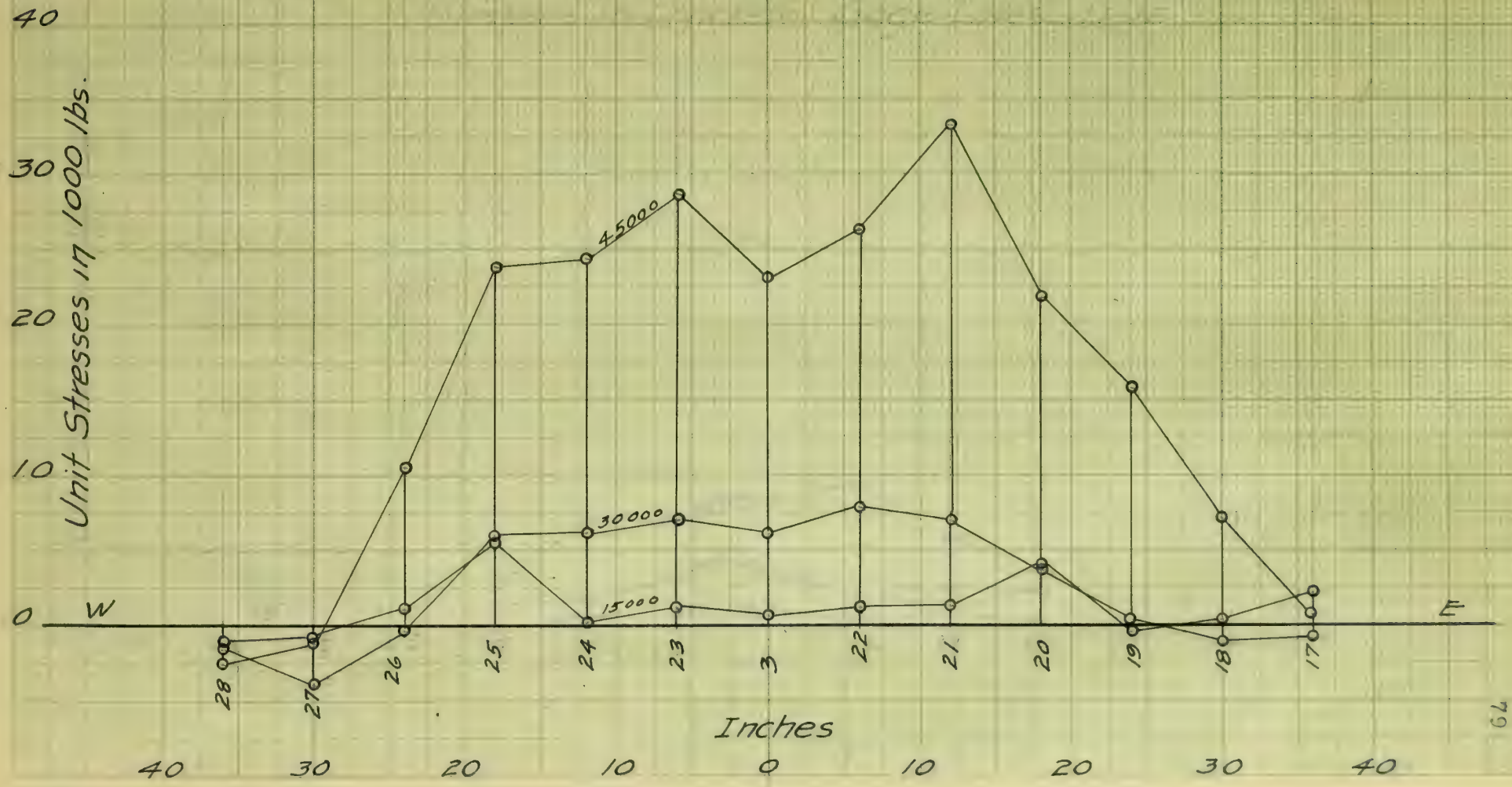
Slab 1251

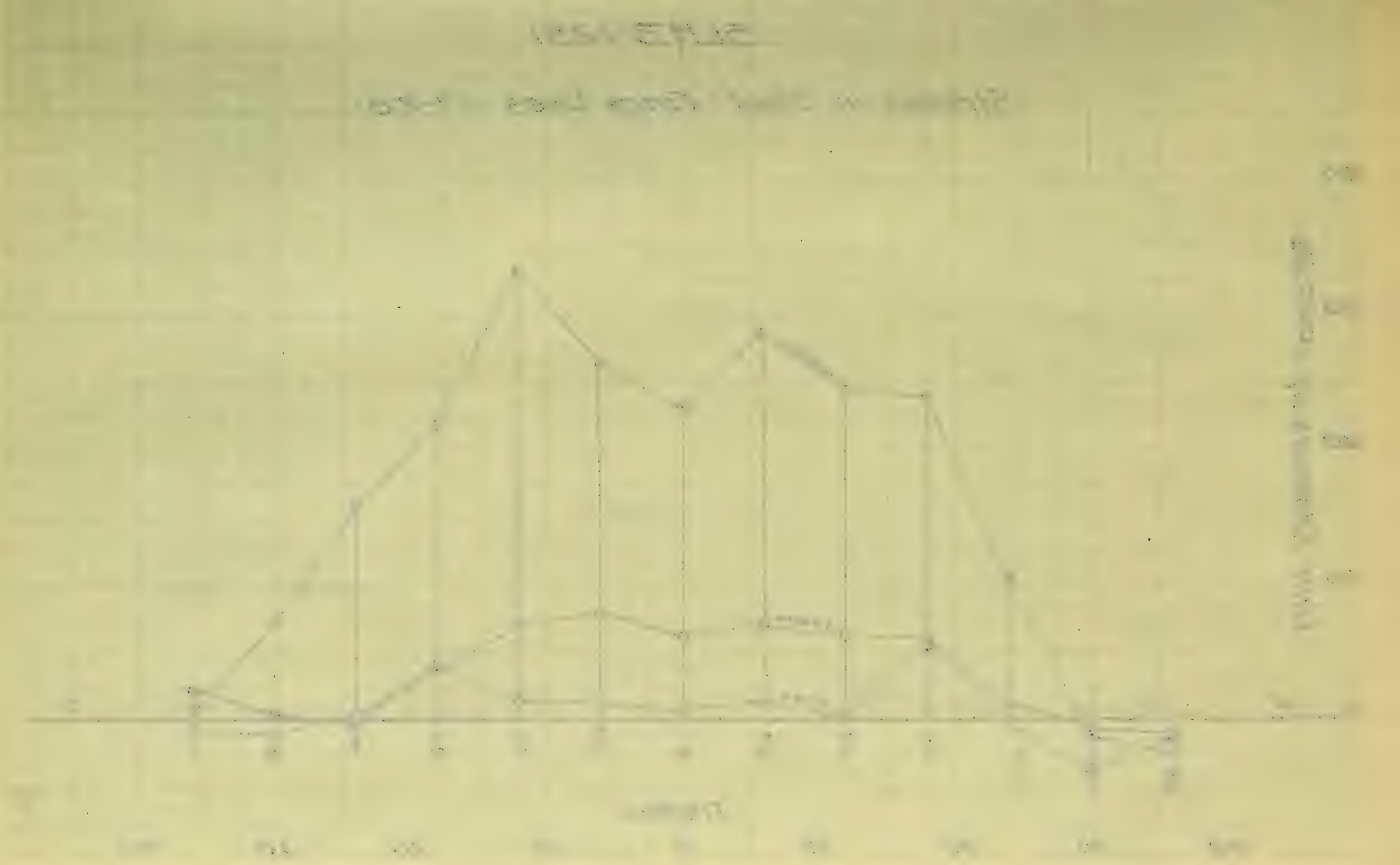
Stresses in Steel Gage Lines 11-16



SLAB 1251

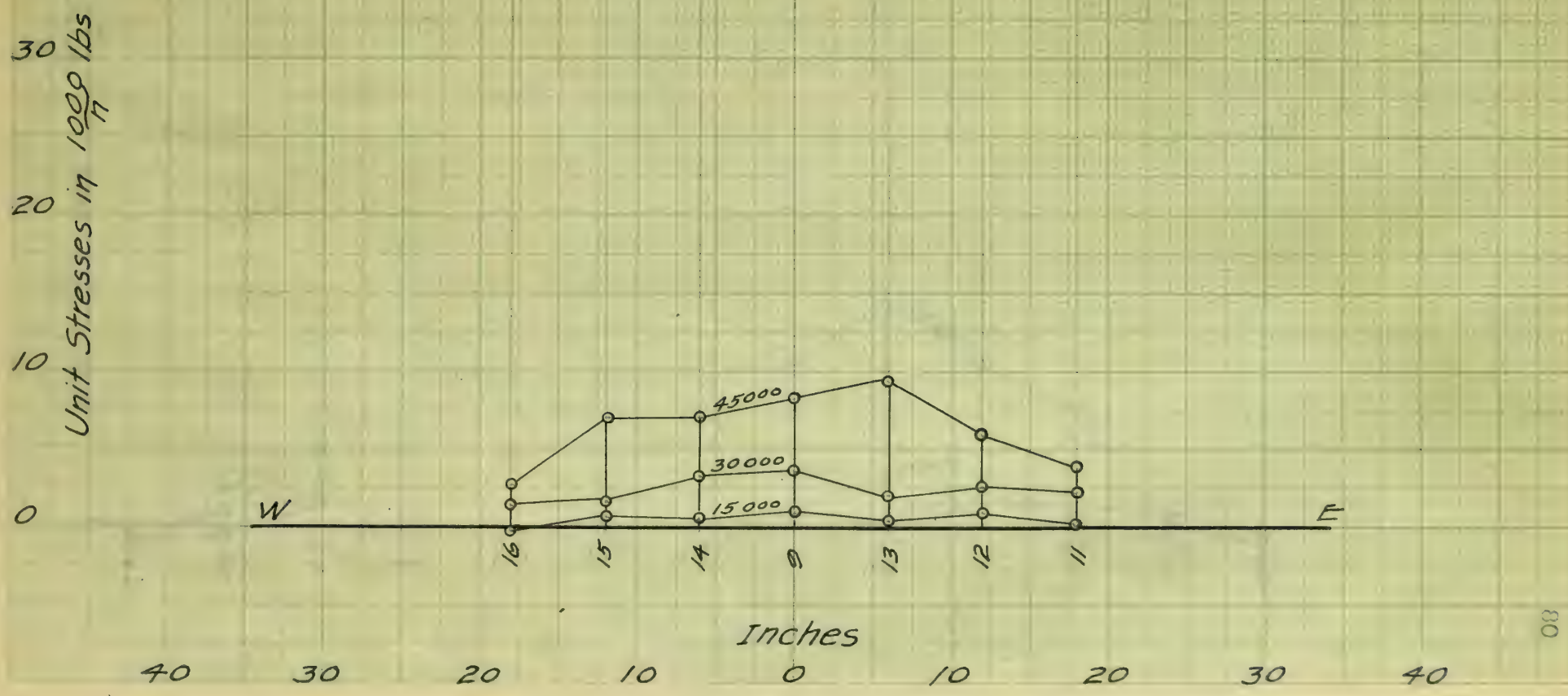
Stresses in Steel Gage Lines 17-28

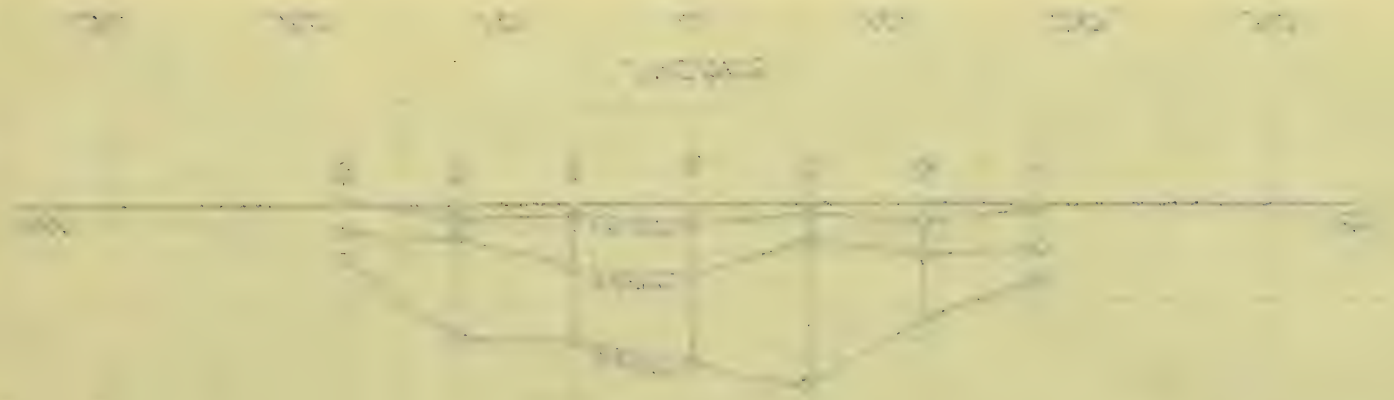




Slab 1251

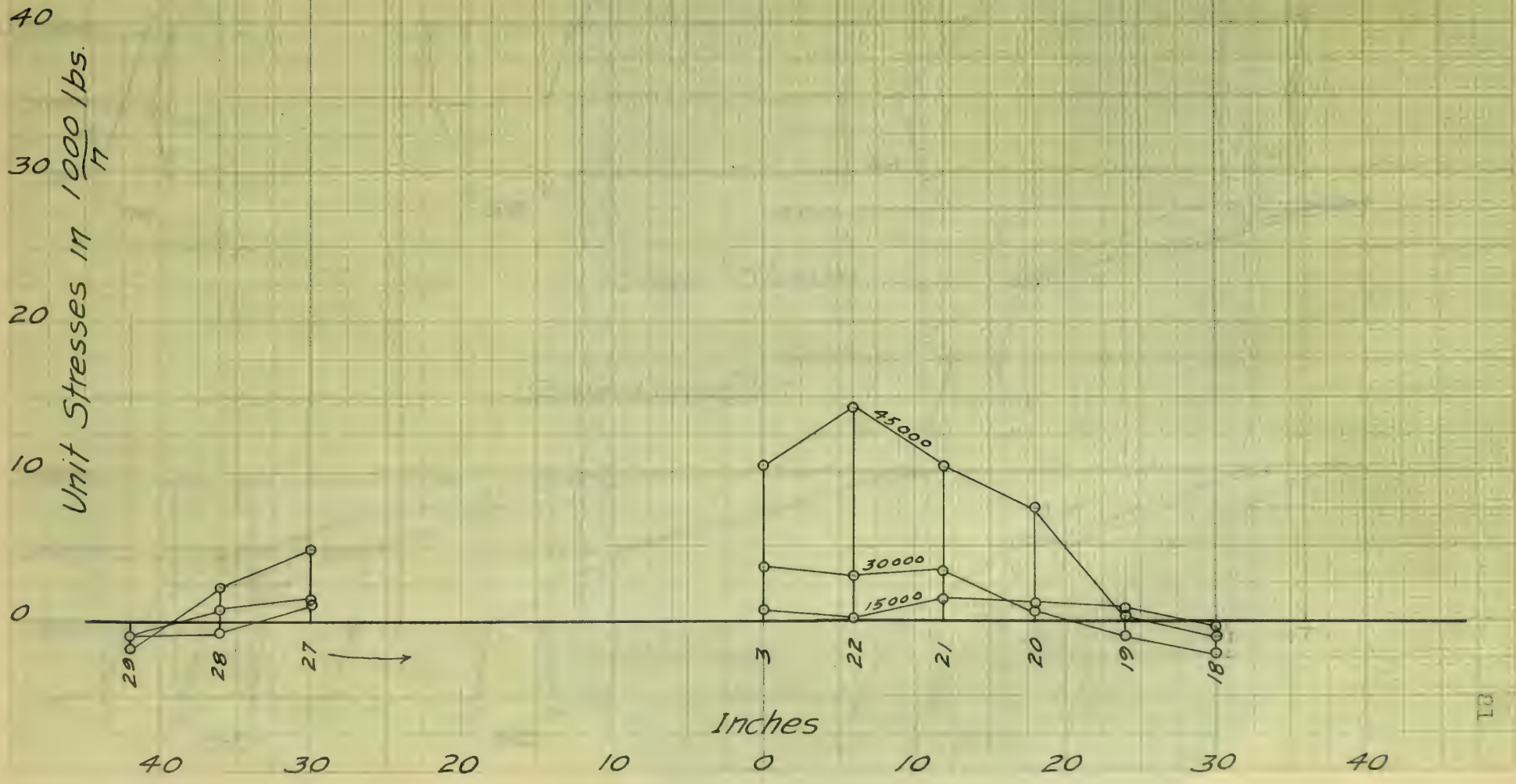
Stresses in Concrete Gage Lines 11-16





SLAB 1251

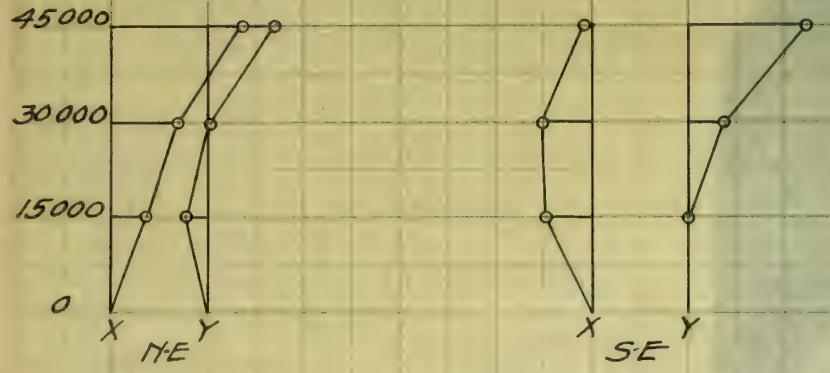
Stresses in Concrete Gage Lines 17-28

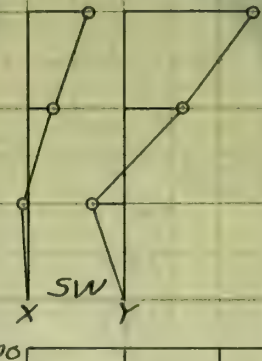


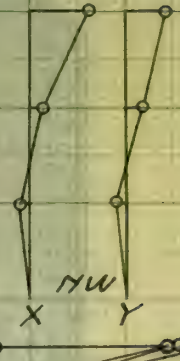
13

Slab 1251

Concrete Stresses Scale 1" = 1000/n lbs. sq. in.

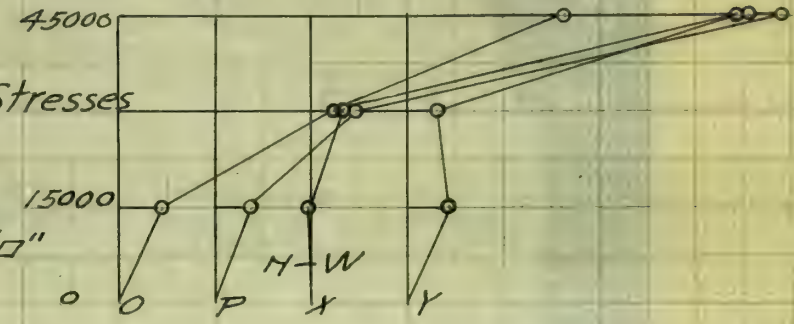


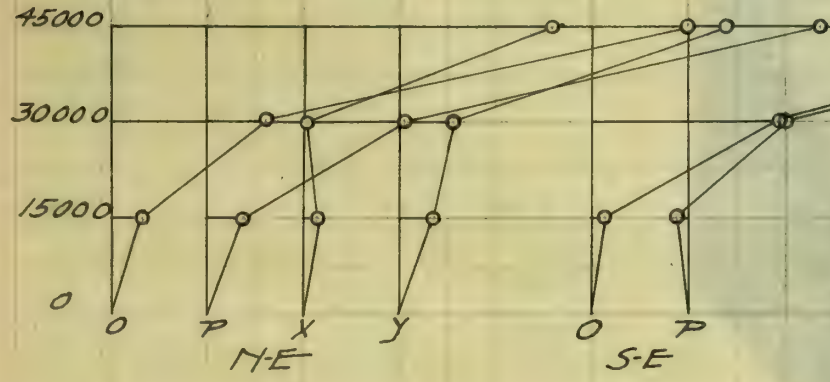


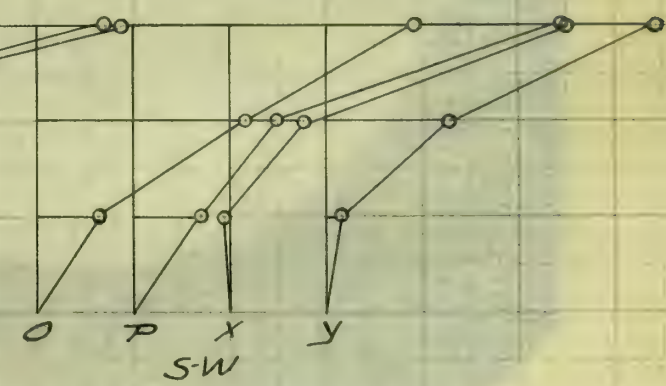


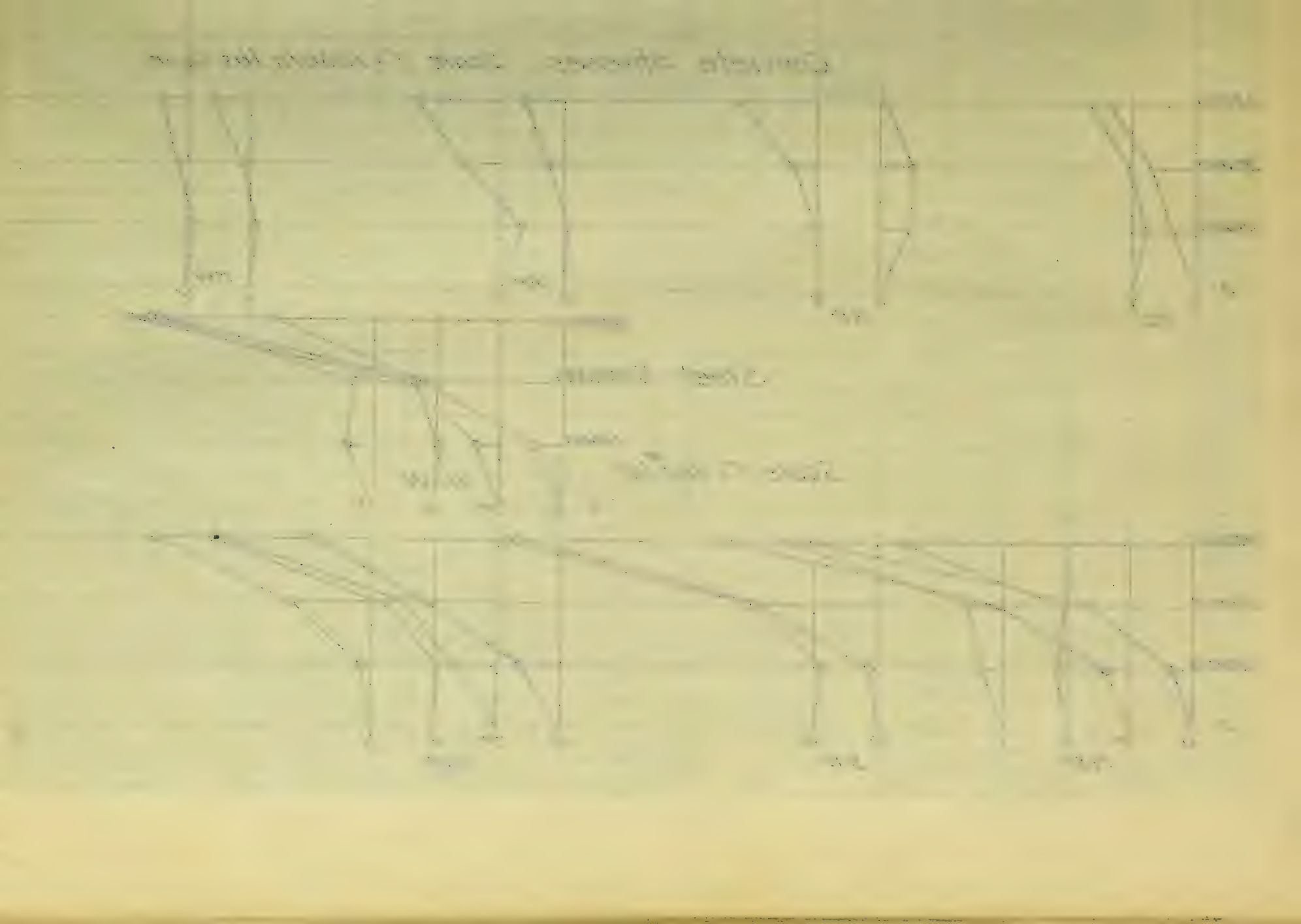
Steel Stresses

Scale - 1" = 1000 #/□"









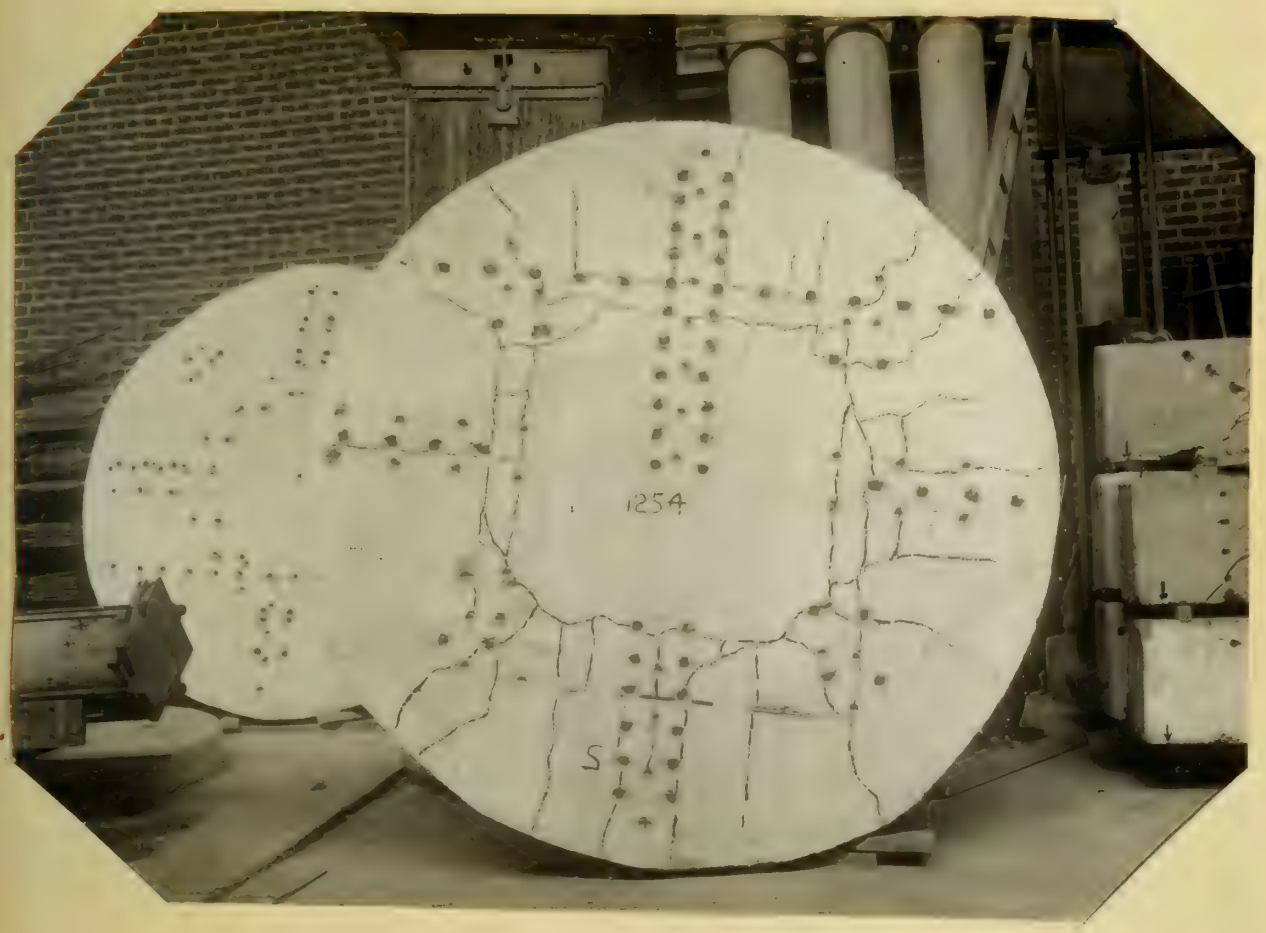


Figure 17.

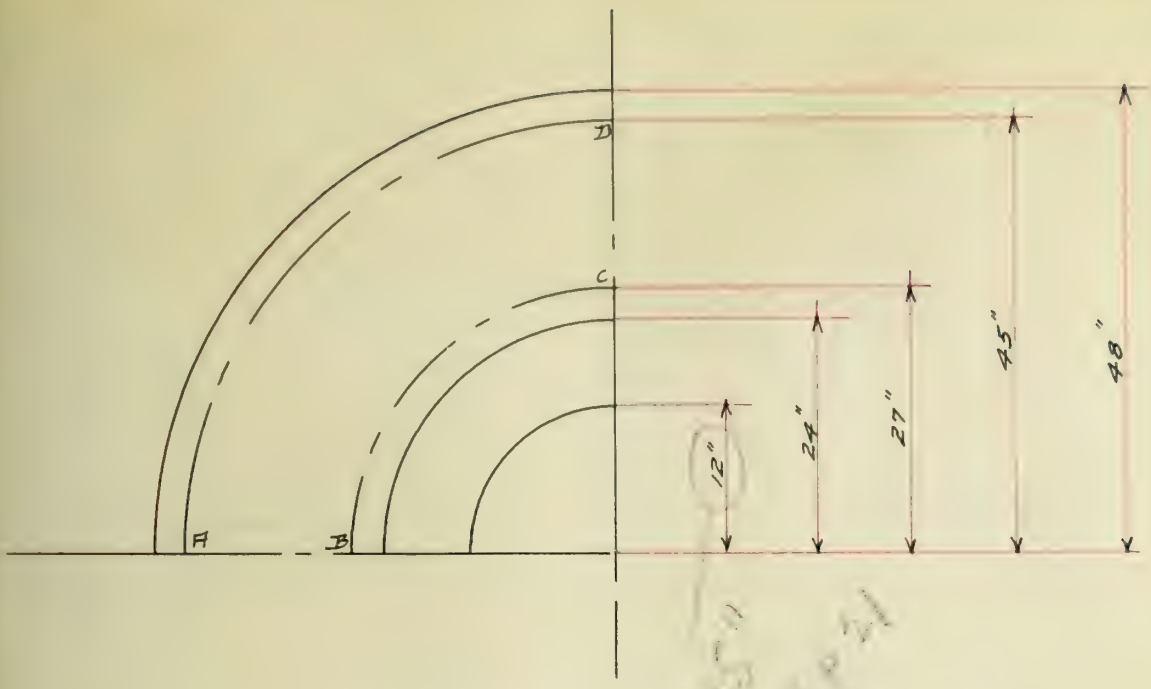
VIEW OF SLAB 1254 AFTER TESTING.

[illegible] Slab 1254. [illegible] of Test.

[illegible] Slab with [illegible] Reinforcement and [illegible] Cap.

Slab 1254 had [illegible] rods with 23-7/16 inch diameter caps [illegible]. A 16 inch cap diameter was the largest cap diameter used, and the large addition to the concrete area of the slab available for compression which was thus afforded, enabled the slab to take a higher load than any of the others tested. Slab 1254 did not get its maximum load although the stresses became quite large, because it was not thought safe to load the machine any higher than 100000 pounds. The circumferential cracks were located further from the center in this slab than in any of the others on account of the greater cap diameter.

[illegible]. Load Deformation Relations. As [illegible], the effect of the large cap-diameter in this specimen was to greatly decrease the deformations at the same loads as those for slabs with a smaller cap diameter and also to increase the maximum load. In every case the stress in the rods is seen to be reduced toward zero over the center of the cap . This phenomenon does not occur in all the [illegible] loads, but is most liable to occur when the cap diameter is large so that there is a sufficient length along the rod between the edge of the cap and the center of the specimen to make the total bond stress equal to the total decrease in the stress on the rod without exceeding the bond stress.



Slab 1254.

Euilibrium Calculations.

The bending moment equals $.707\frac{(45-27)}{4}80000$ or 256000 inch pounds, in the direction CD on the section ABC. (M=80000 #)

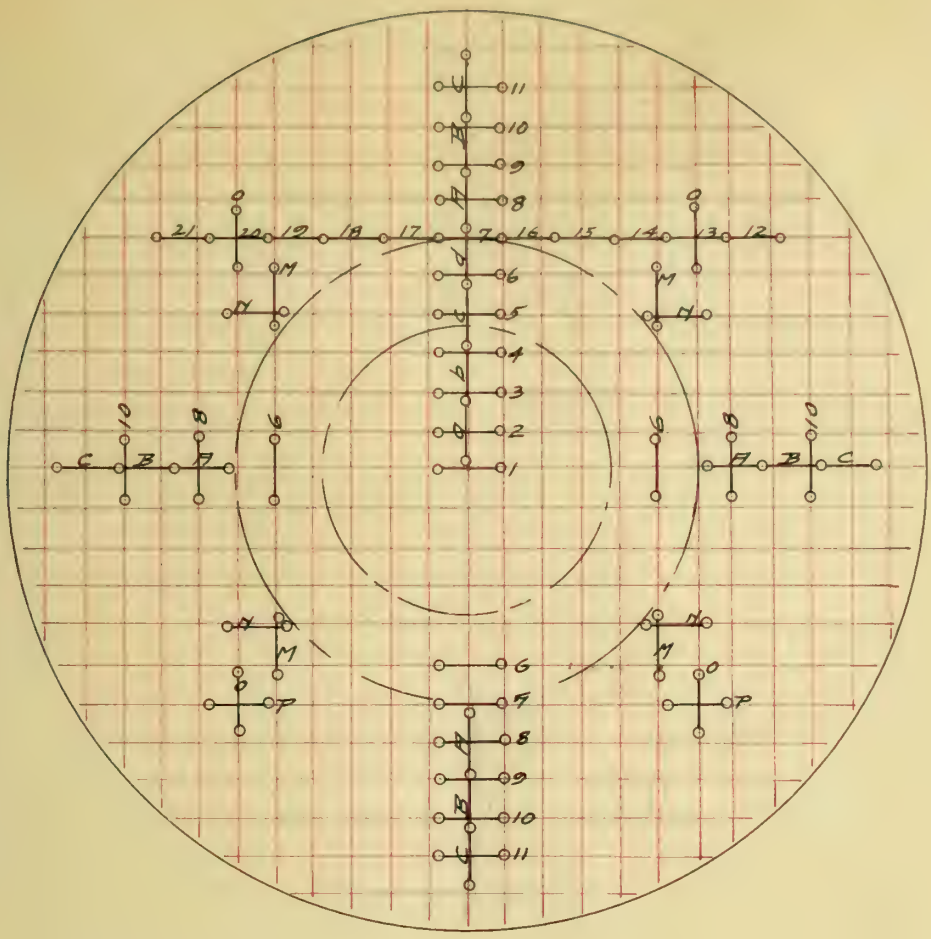
$11\frac{1}{2}$- 7/16 inch diam. rods cut the section.

A_s equals 1.73 sq. inches.

The average steel stress for the load of 80000 pounds equals 24000 pounds per sq. inch on all the rods cutting the section ABC in the direction CD.

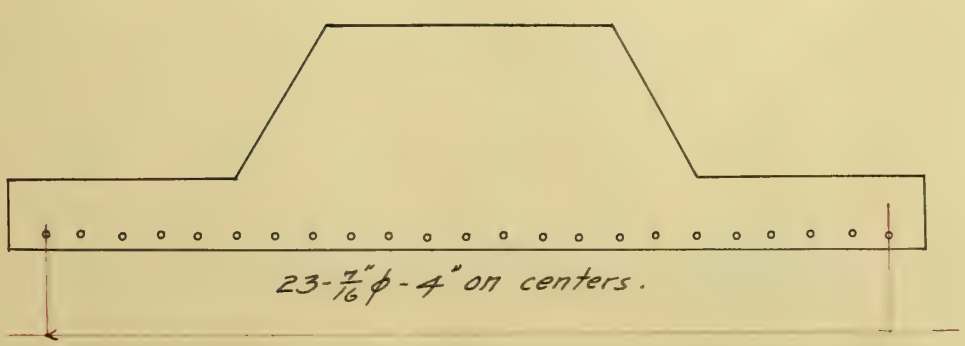
Therefore the effective depth or jD becomes

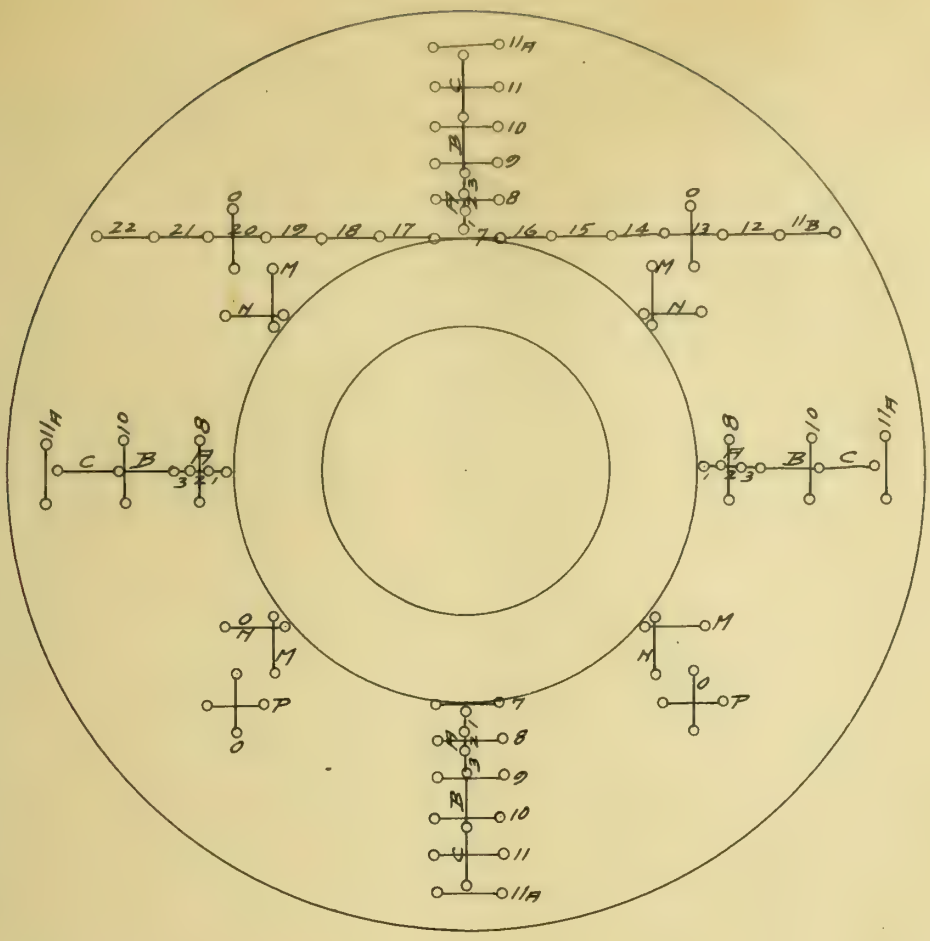
256000/1.73(24000) or 6.15 inches.



Gage Lines in the Steel. Slab 1254.

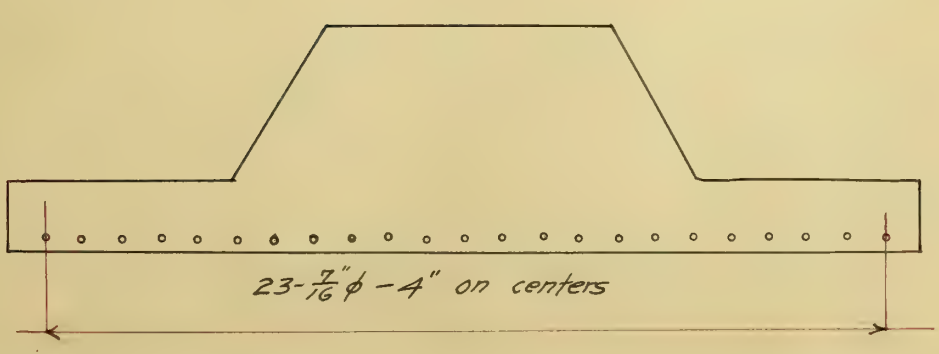
Figure 18.

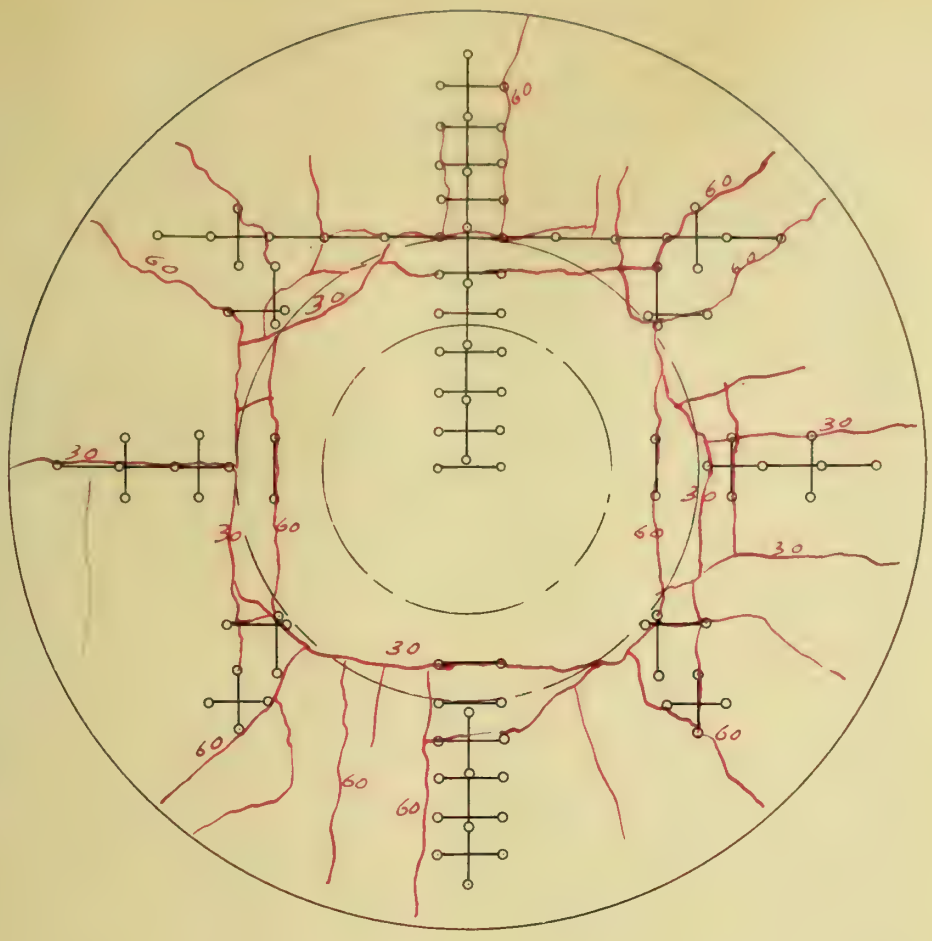




Gage Lines in the Concrete. Slab 1254.

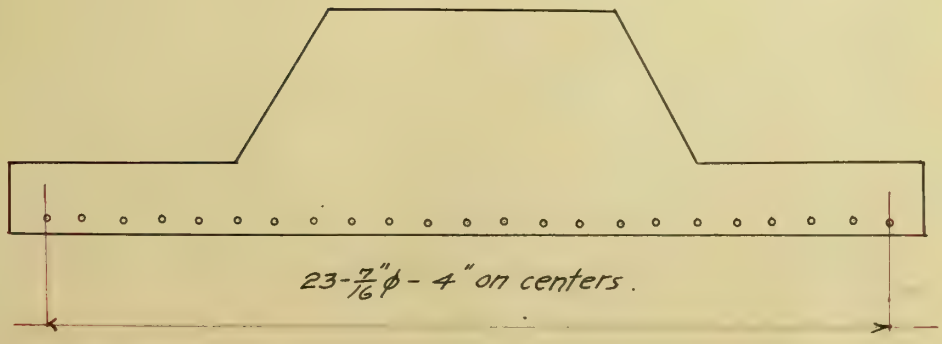
Figure 19.

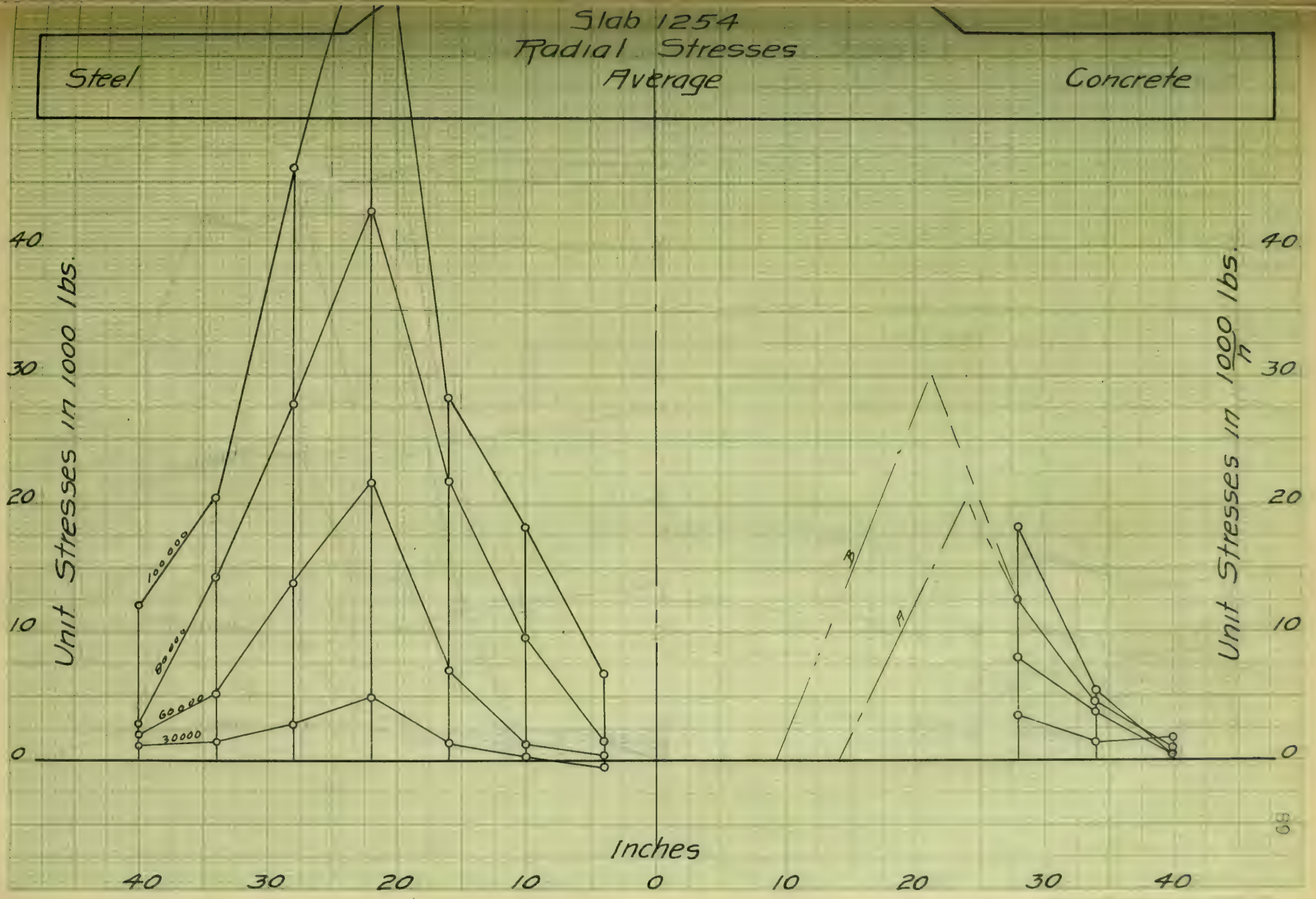


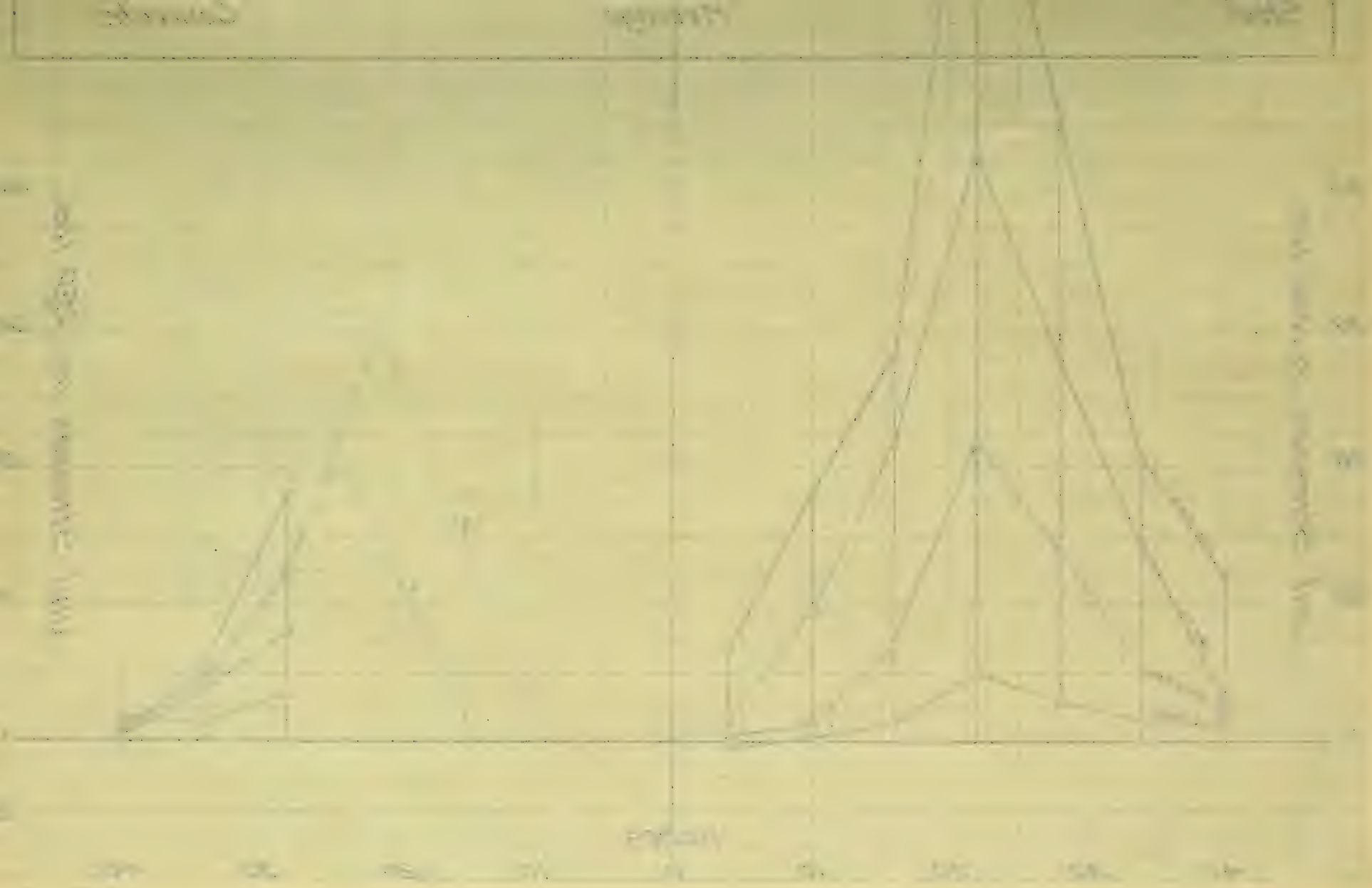


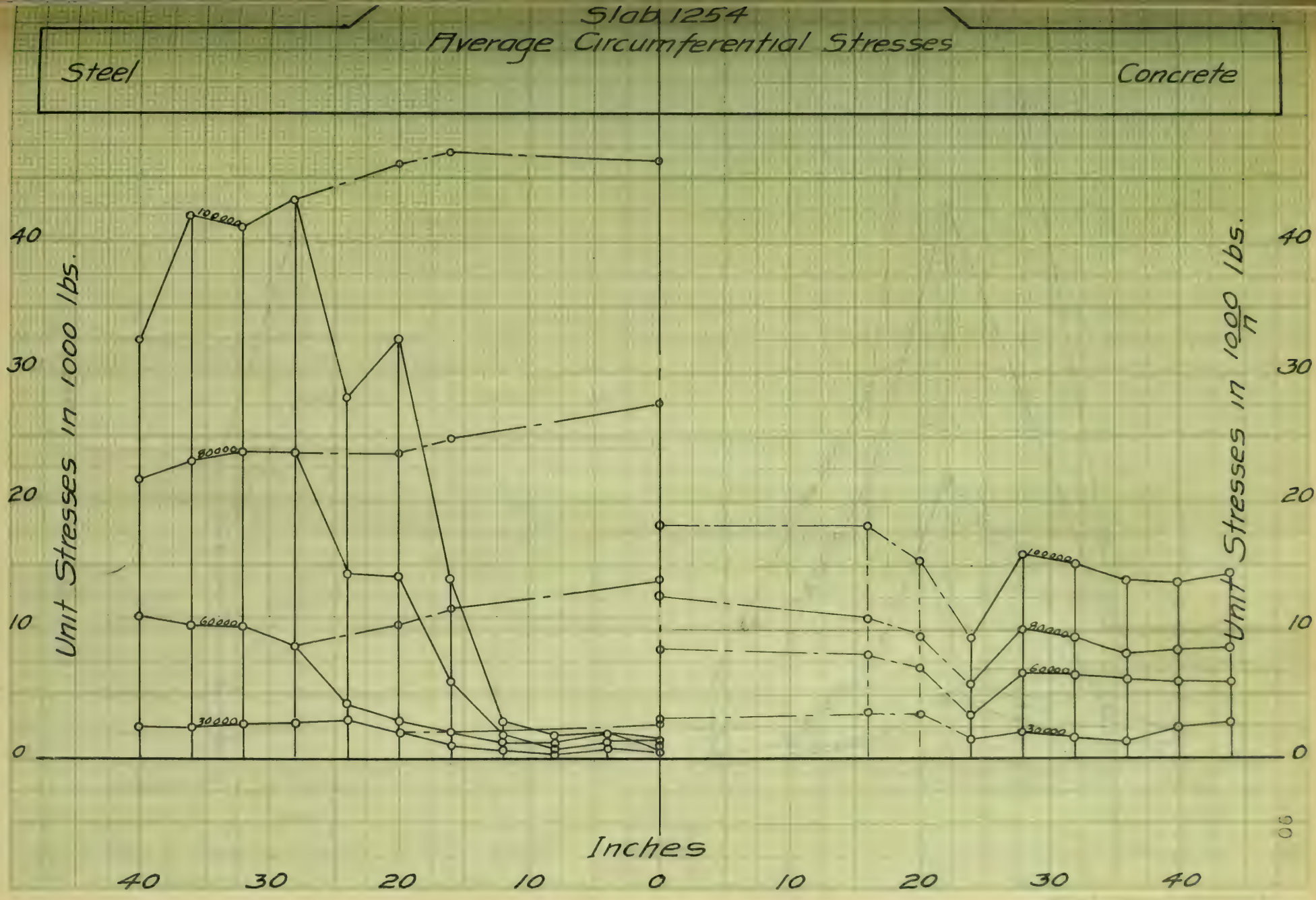
Sketch of Cracks. Slab 1254.

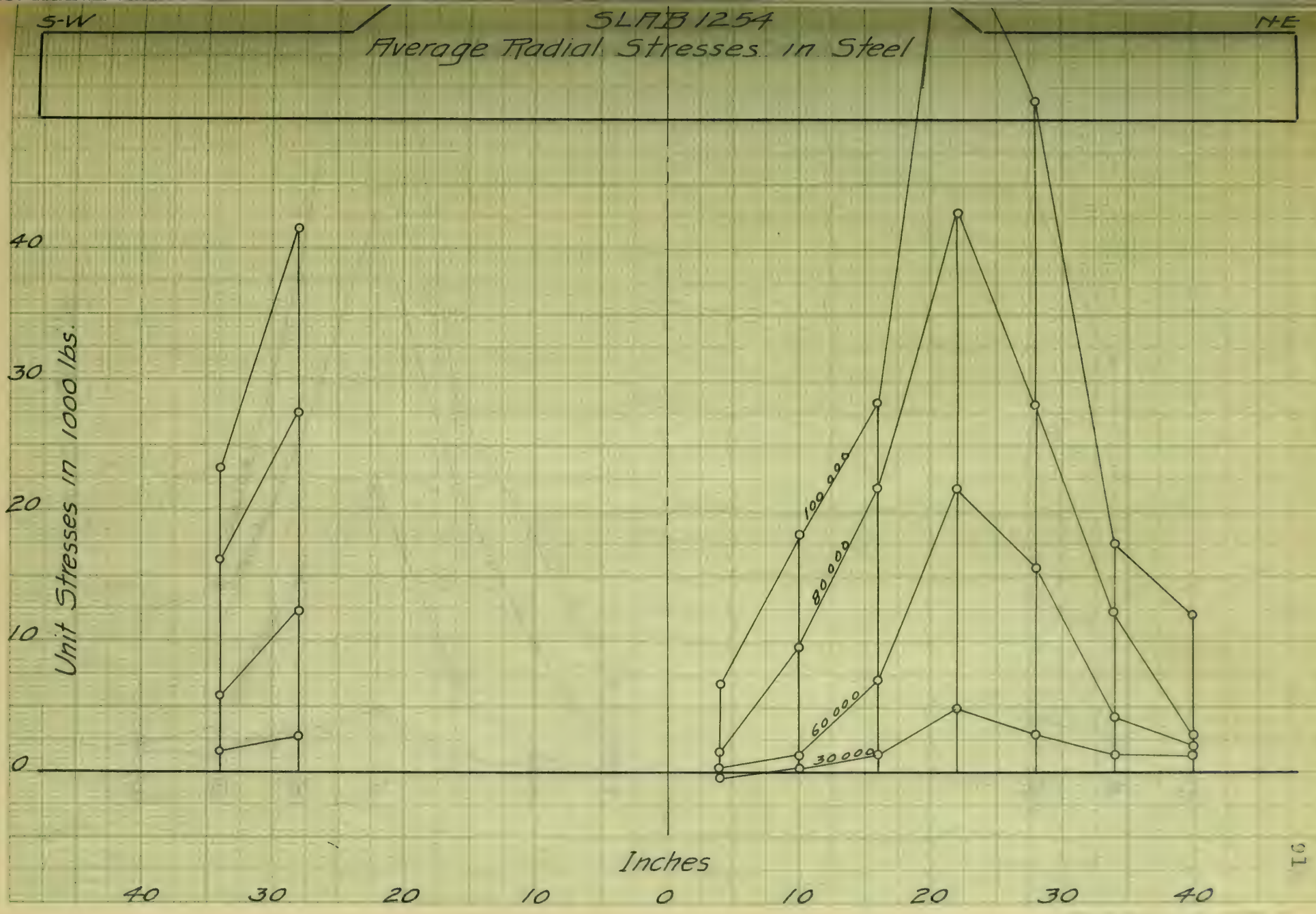
Figure 20.

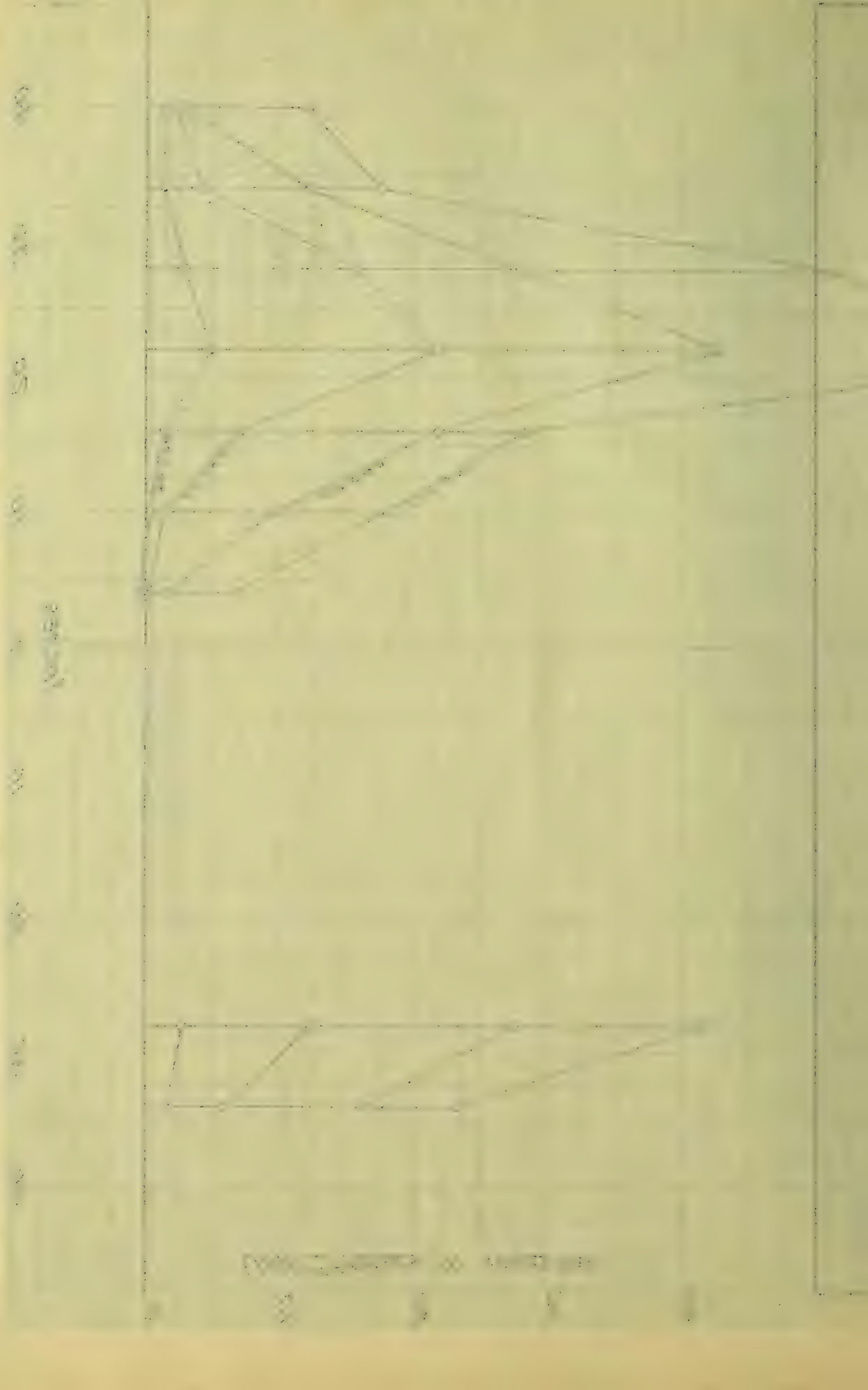


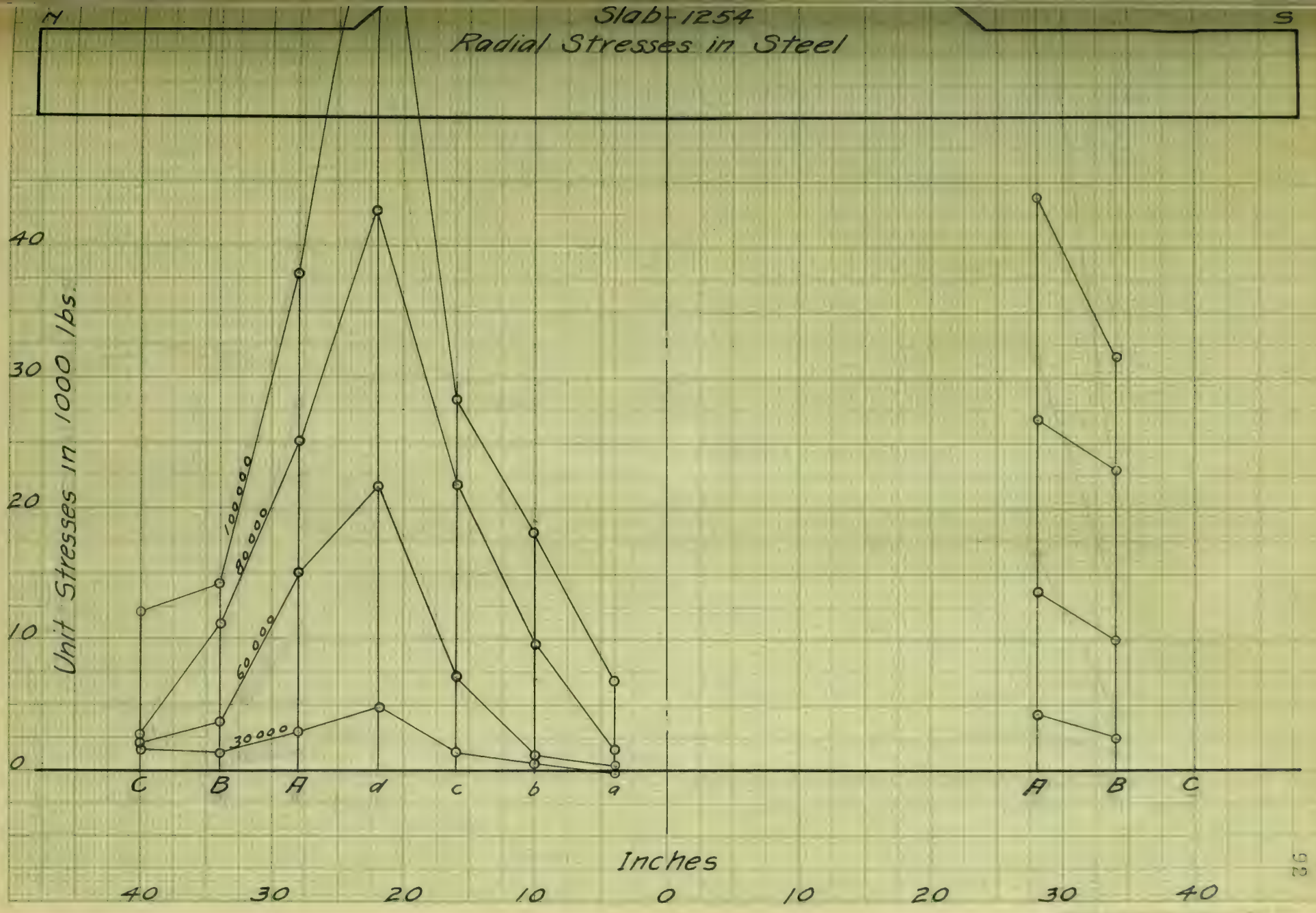

Slab 1254
Radial Stresses
Average
Steel
Concrete
Unit Stresses in 1000 lbs.
40
30
20
10
0
100 000
80 000
60 000
30000
B
A
Unit Stresses in 1000 lbs.
Inches
40
30
20
10
0
10
20
30
40

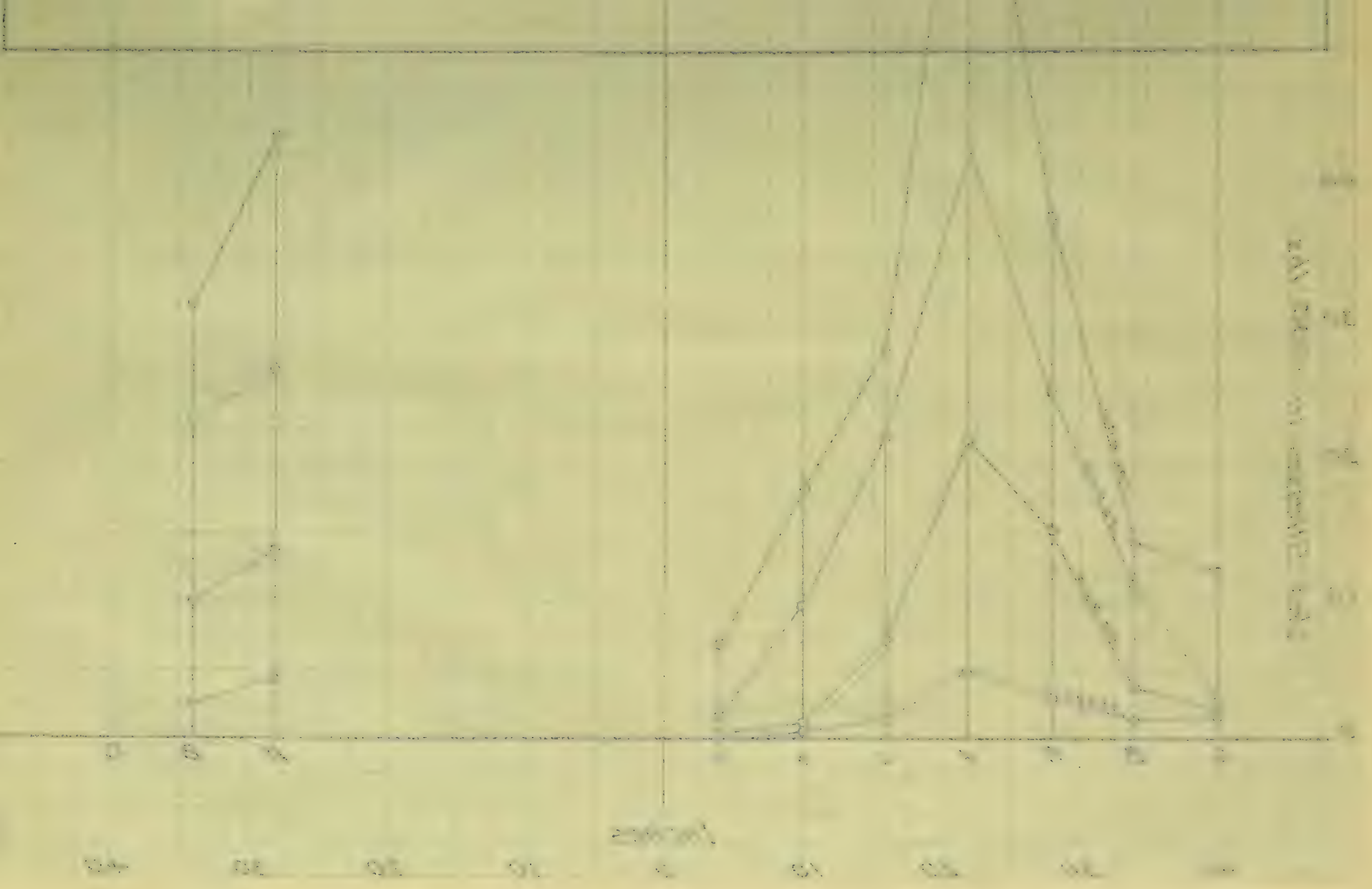


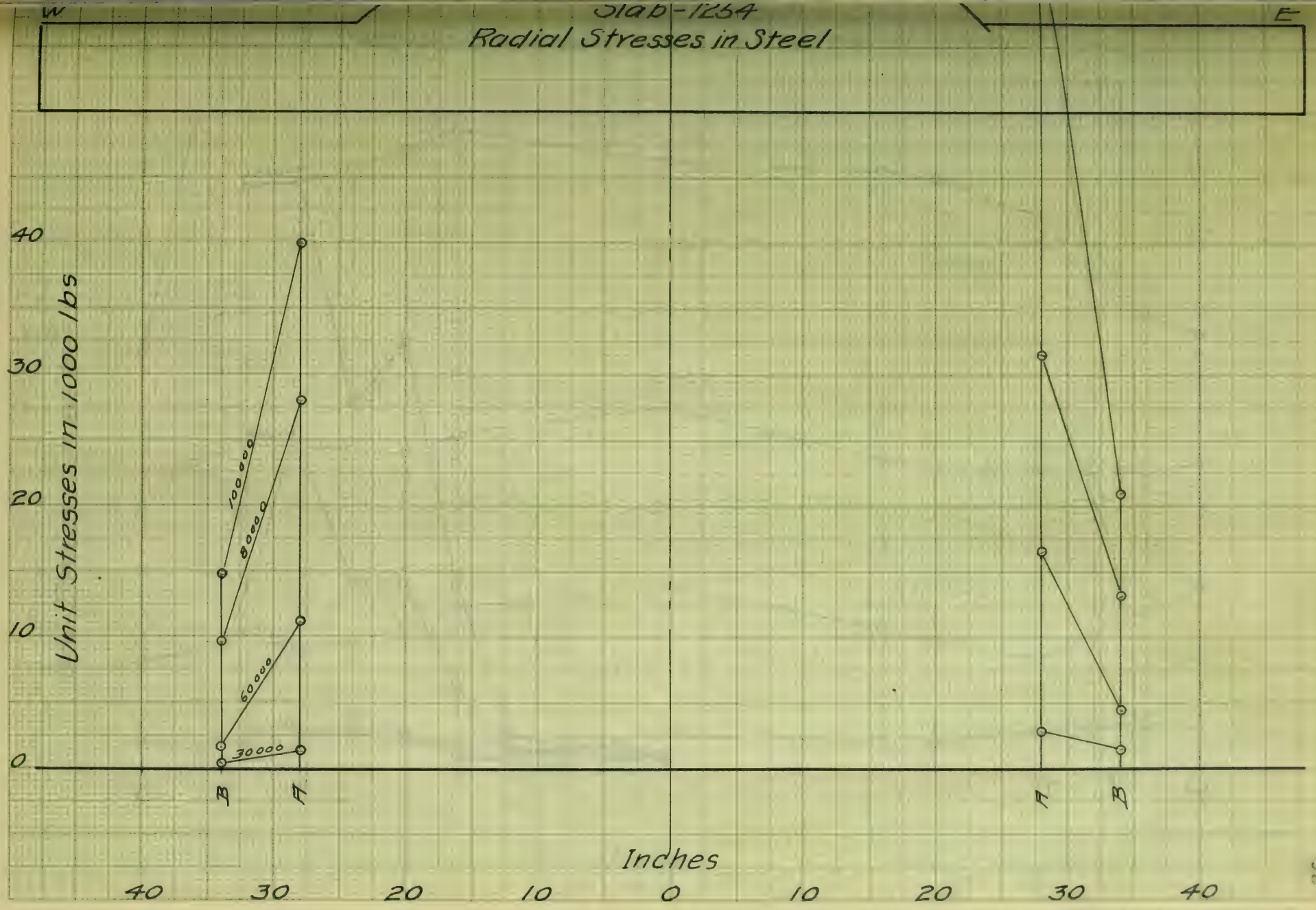

Slab 1254
Average Circumferential Stresses
Steel
Concrete
Unit Stresses in 1000 lbs.
Unit Stresses in 1000 lbs.
100000
80000
60000
30000
40
30
20
10
0
Inches
40
30
20
10
0
10
20
30
40


S-W
SLAB 1254
Average Radial Stresses in Steel
N-E
40
30
20
10
0
Unit Stresses in 1000 lbs.
100 000
80 000
60 000
30 000
Inches
40
30
20
10
0
10
20
30
40



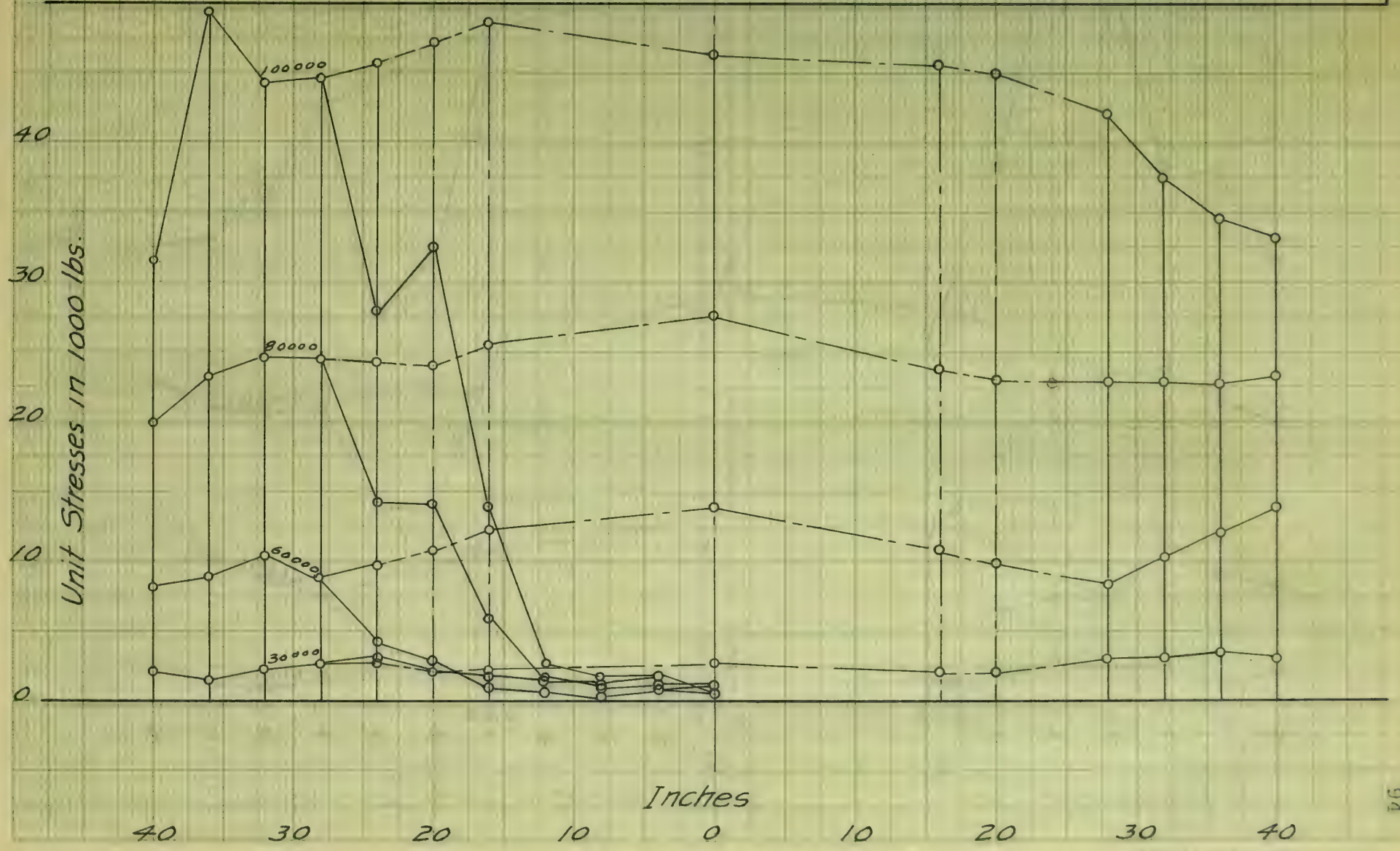

N
Slab-1254
Radial Stresses in Steel
S
40
30
20
10
0
Unit Stresses in 1000 lbs.
100000
80000
60000
30000
C
B
A
d
c
b
a
A
B
C
Inches
40
30
20
10
0
10
20
30
40

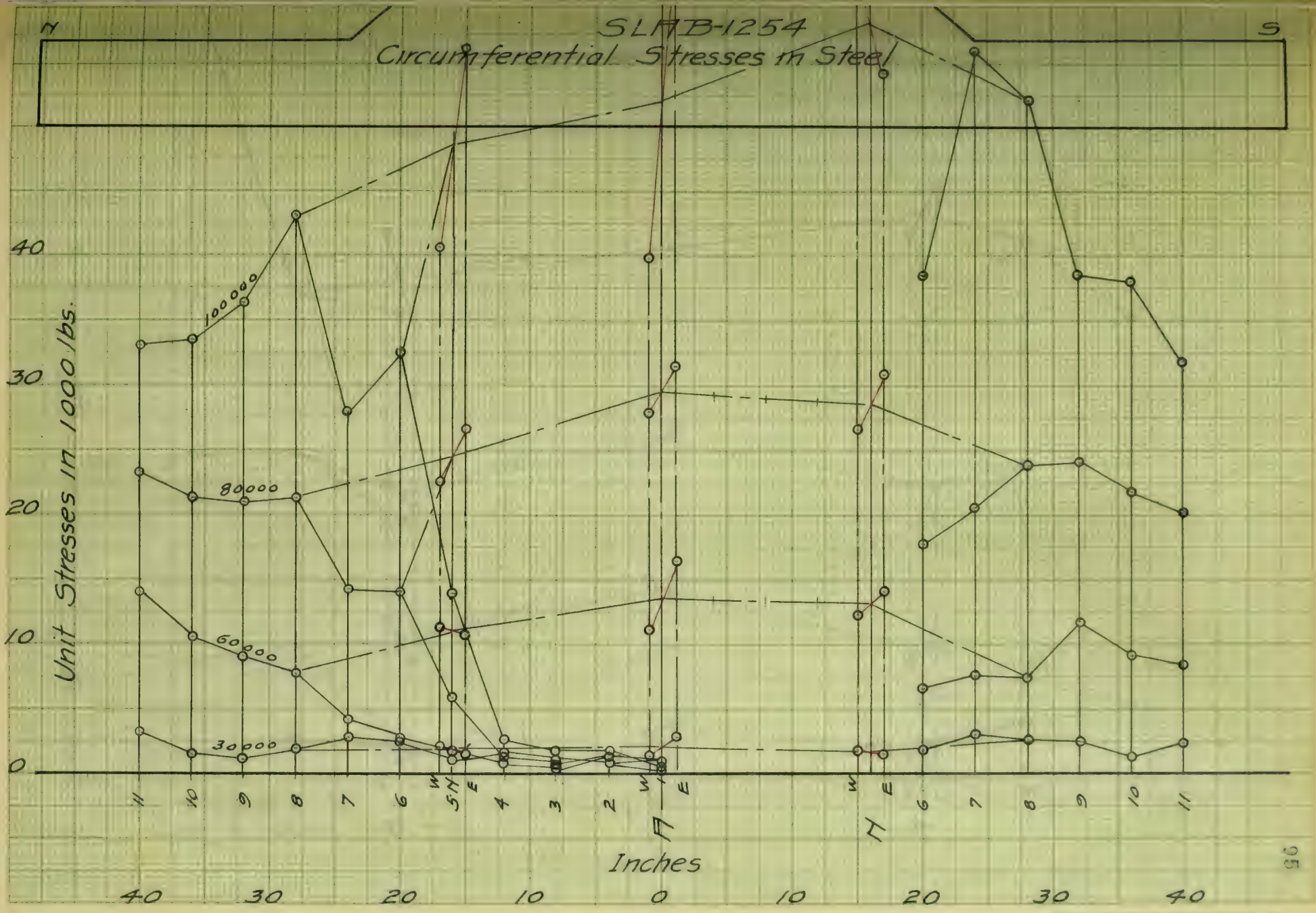


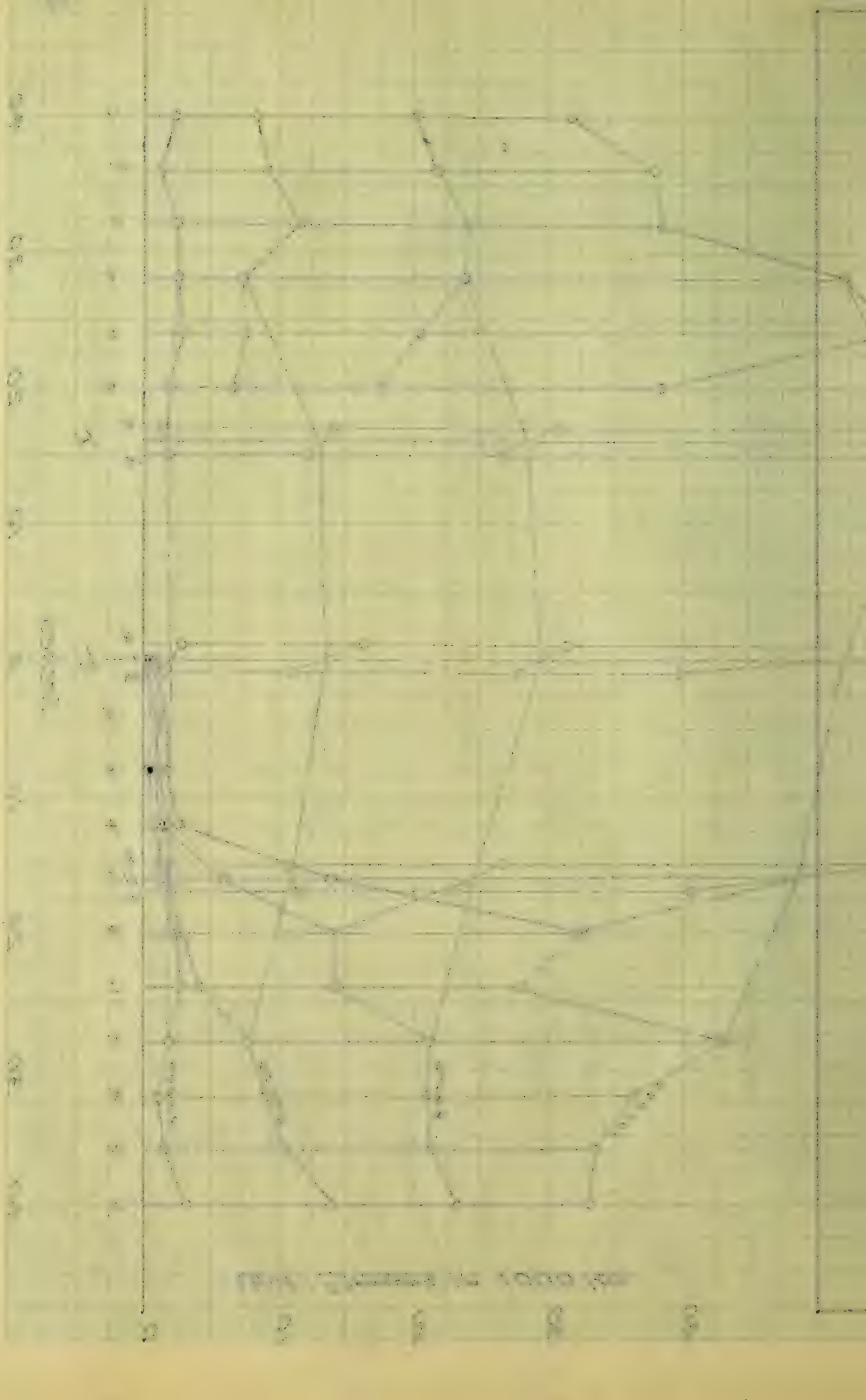

W
Slab-1254
Radial Stresses in Steel
E
40
30
20
10
0
Unit Stresses in 1000 lbs
100000
80000
60000
30000
B
A
A
B
Inches
40
30
20
10
0
10
20
30
40

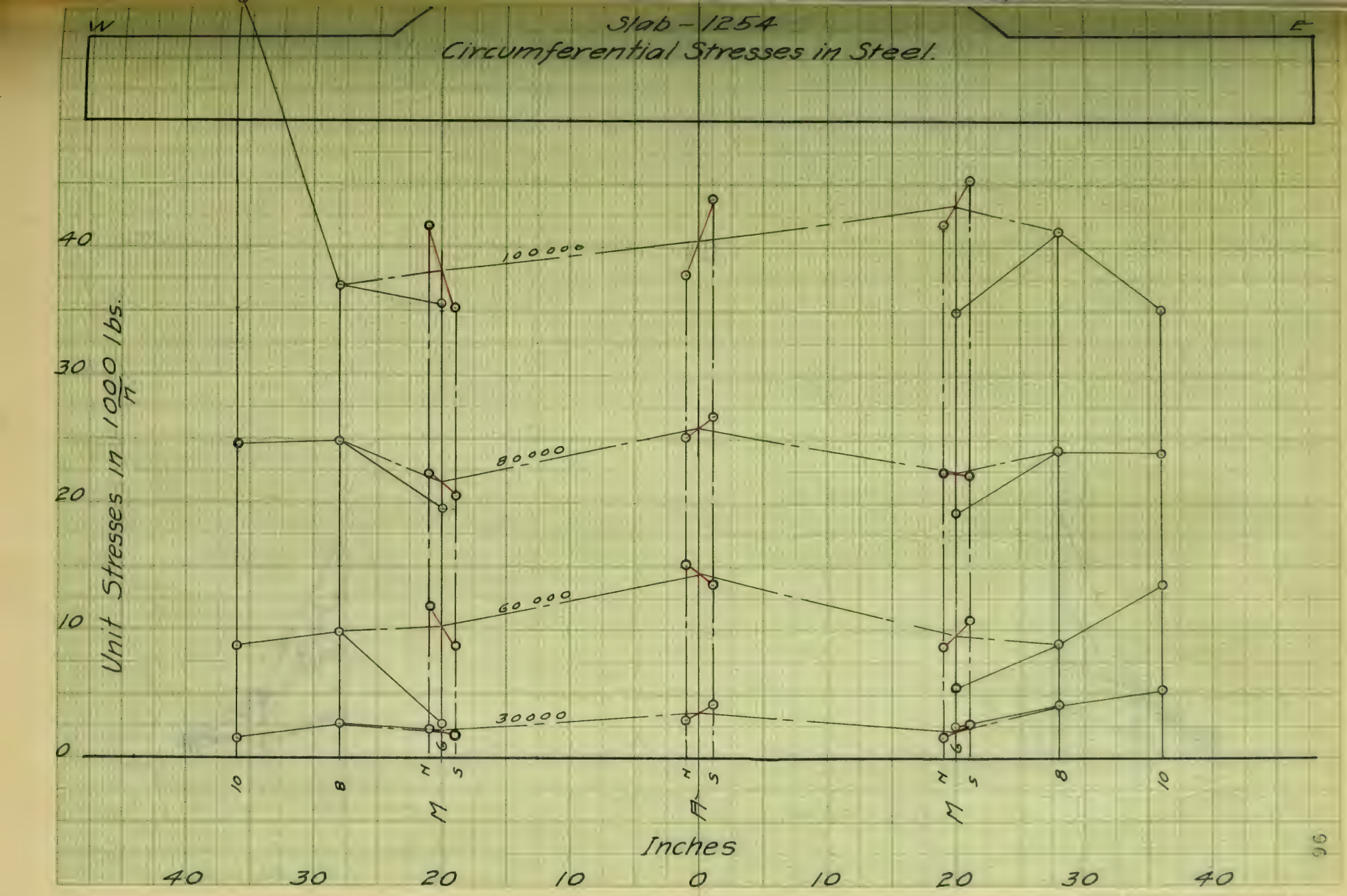
SW SLAB 1254 NE

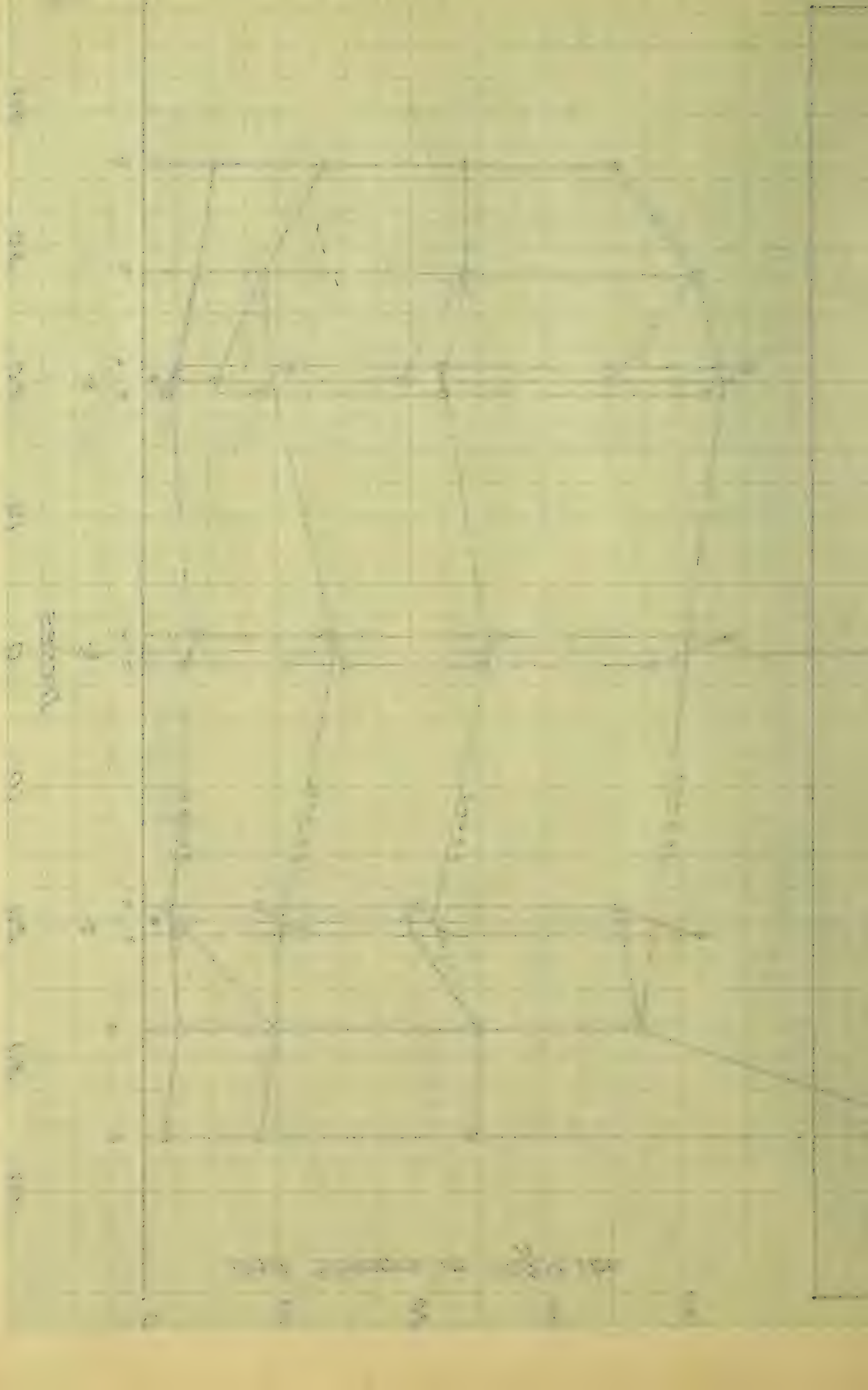
Average Circumferential Stresses in Steel




N
SLAB-1254
Circumferential Stresses in Steel
S
40
30
20
10
0
Unit Stresses in 1000 lbs.
100000
80000
60000
30000
11
10
9
8
7
6
W
S
N
E
4
3
2
W
E
W
E
6
7
8
9
10
11
A
H
Inches
40
30
20
10
0
10
20
30
40




W
Slab – 1254
Circumferential Stresses in Steel.
E
100000
80000
60000
30000
40
30
20
10
0
Unit Stresses in 1000 lbs.
10
8
N
S
M
N
S
N
S
8
10
Inches
40
30
20
10
0
10
20
30
40

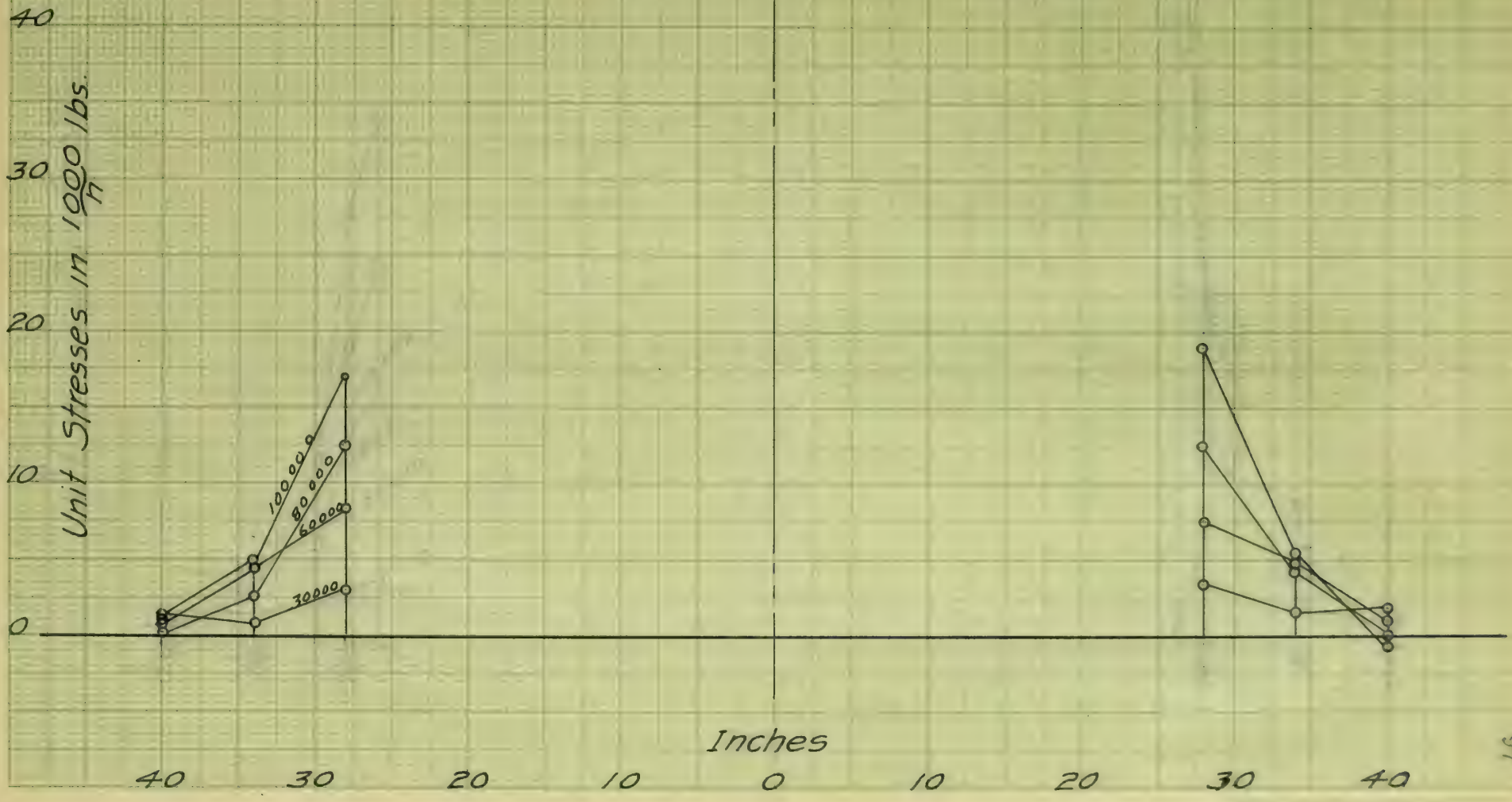


S-W

SLAB 1254

N-E

Average Radial Stresses in Concrete



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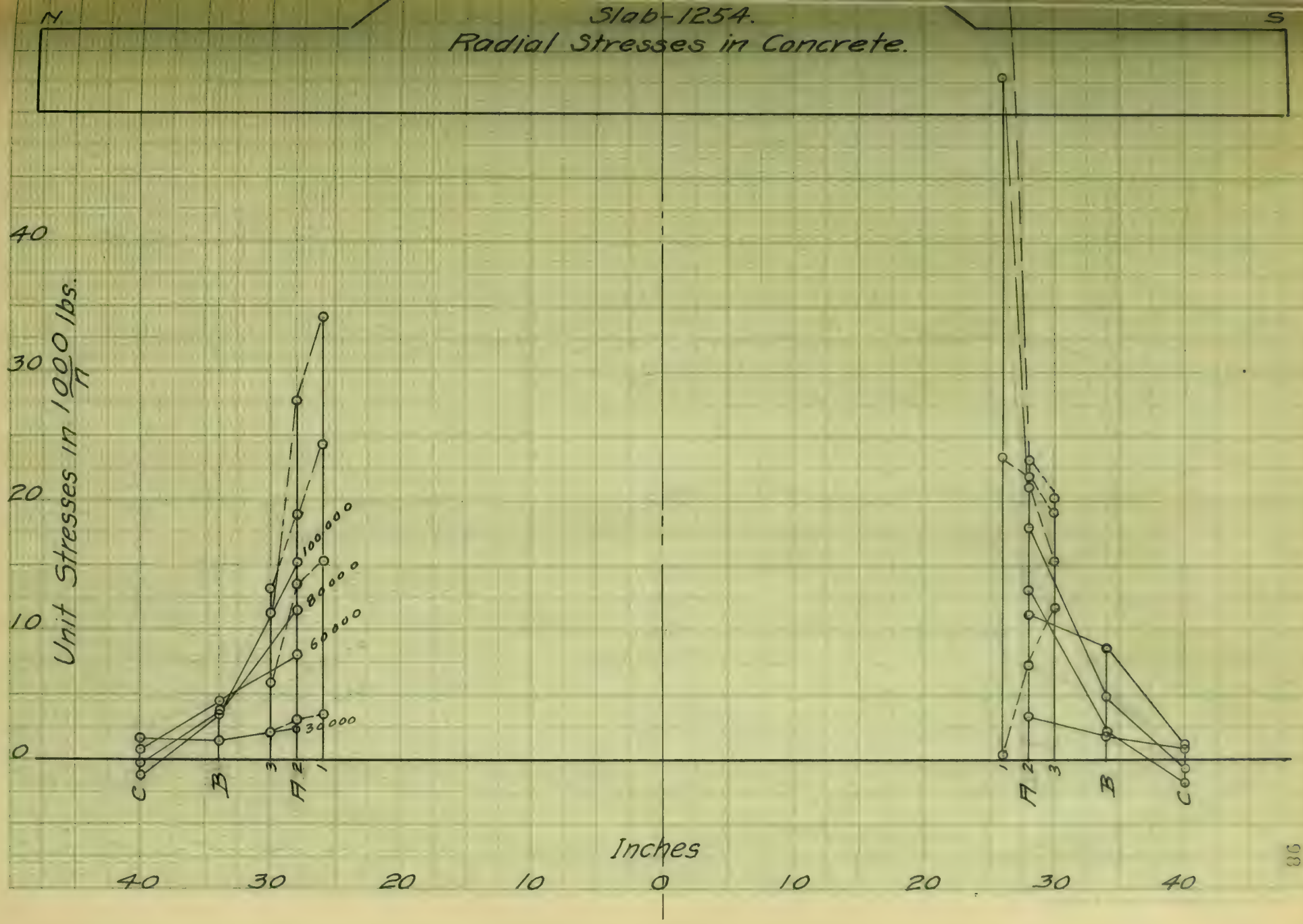
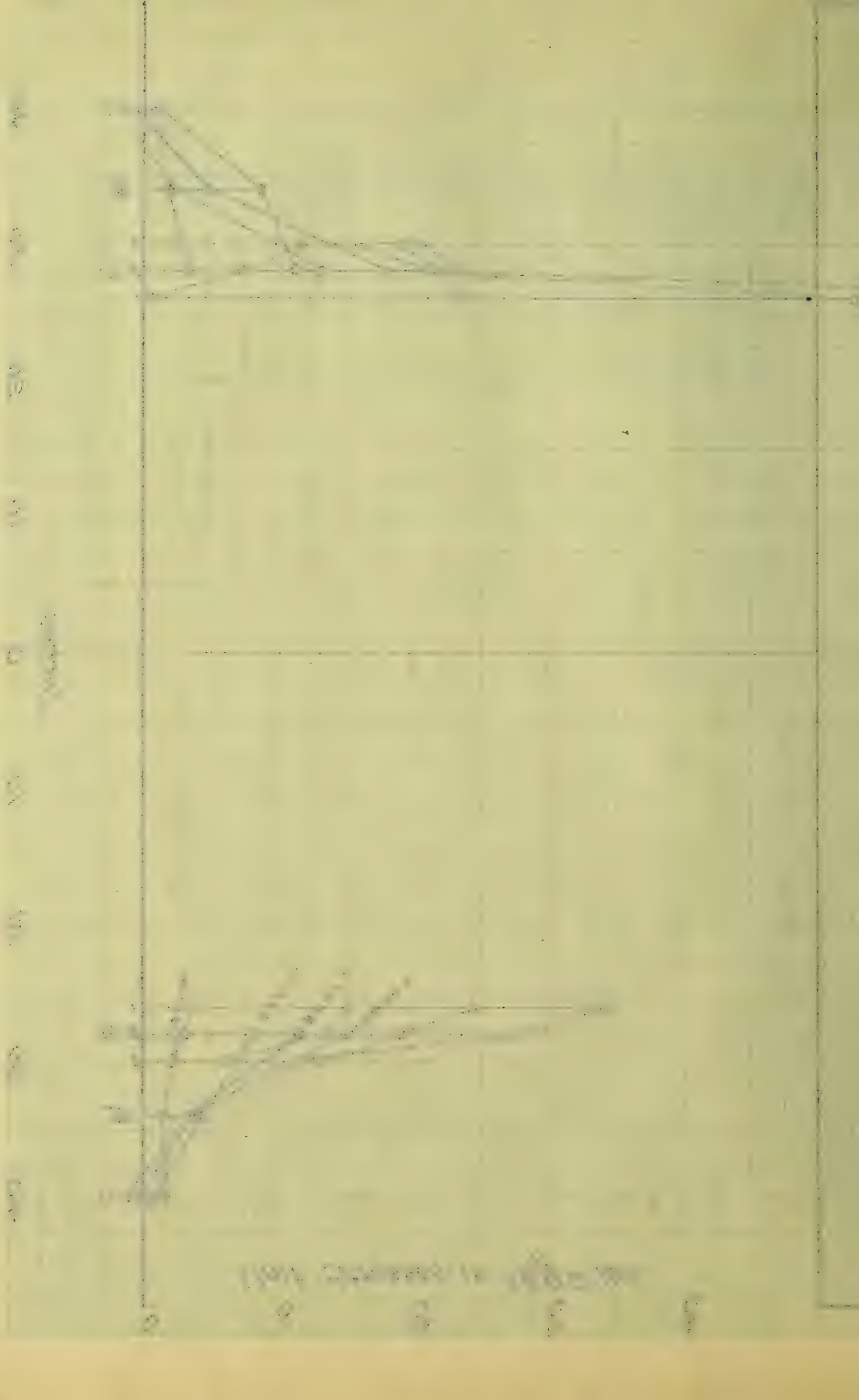
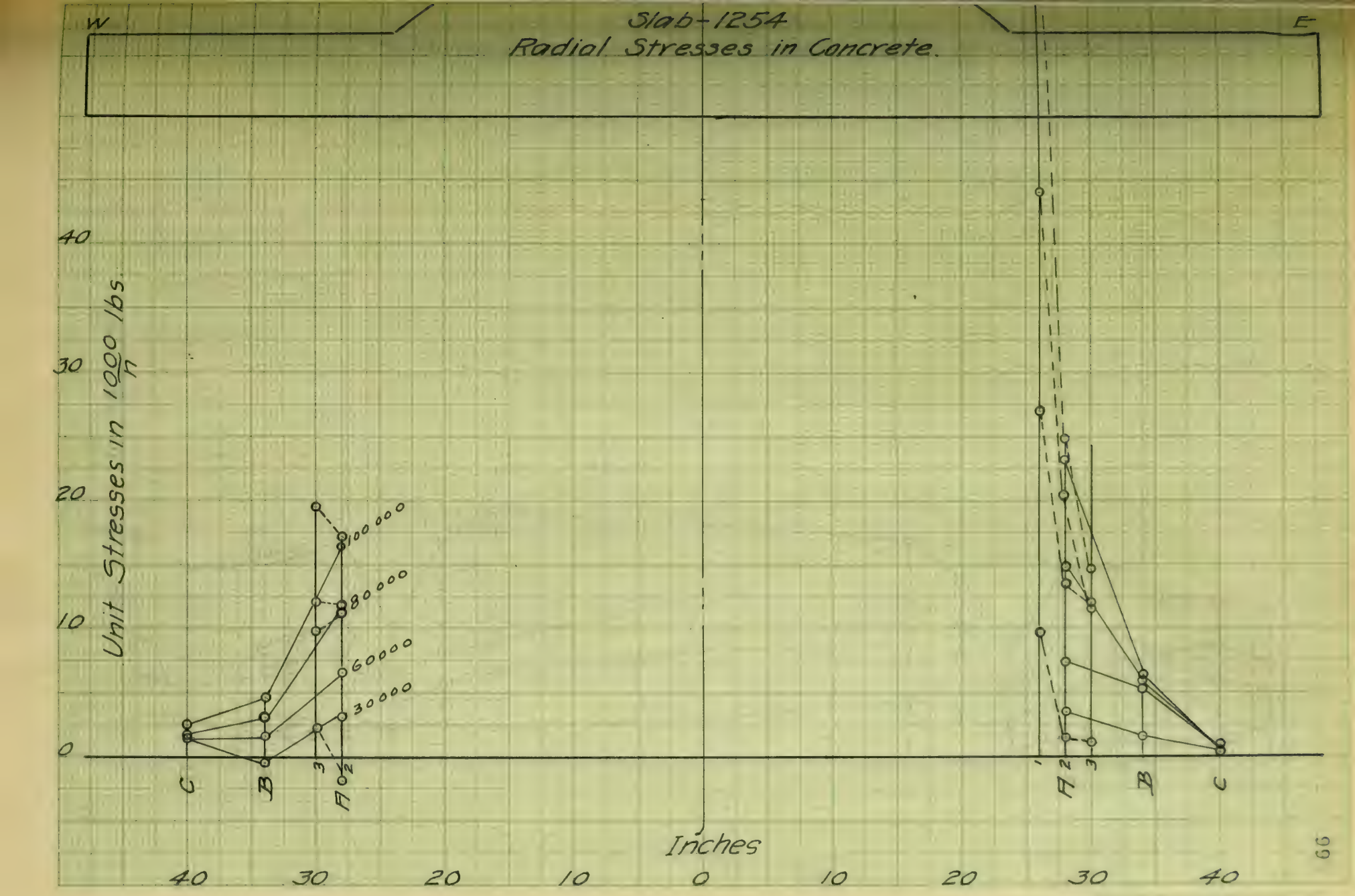
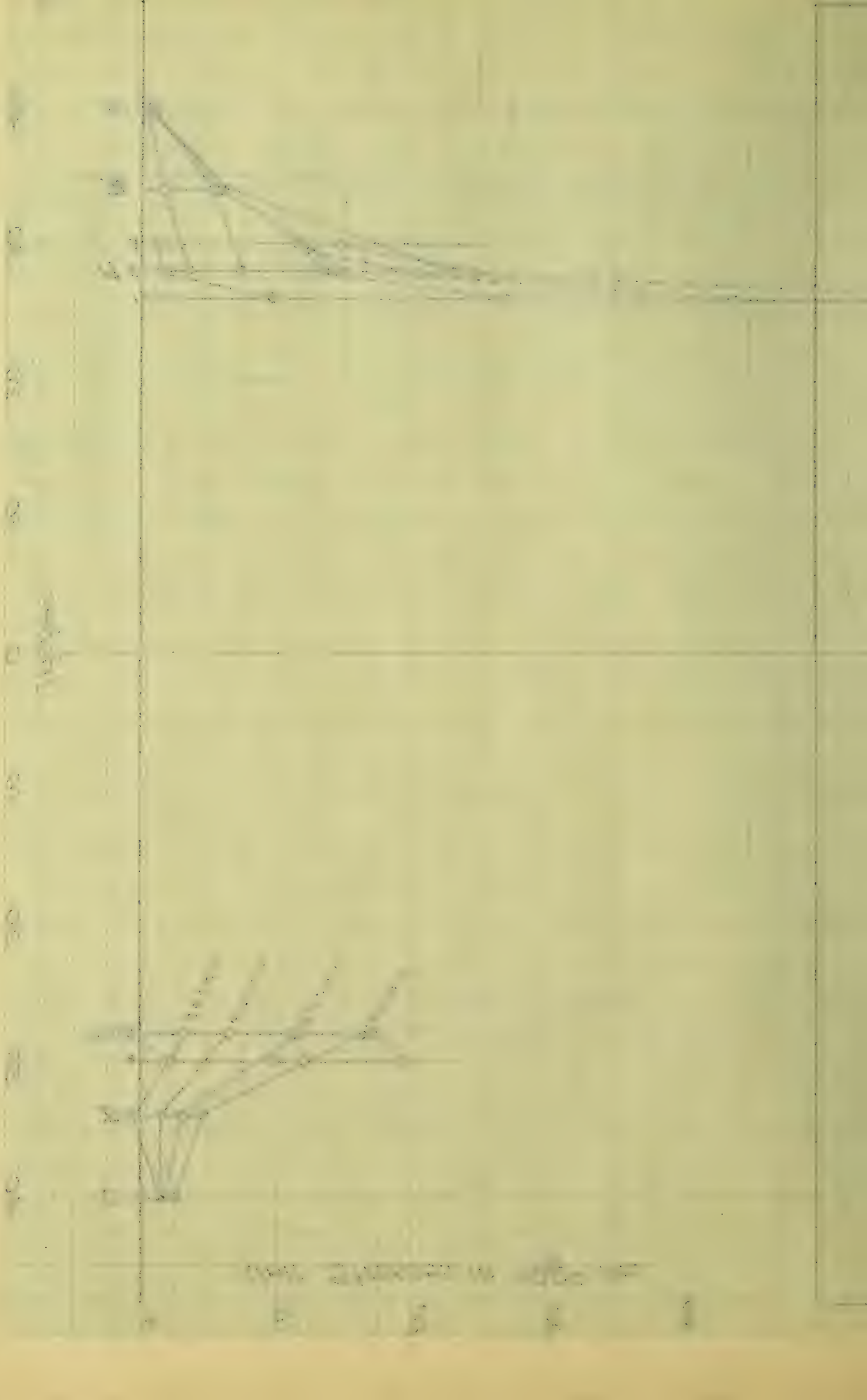

Slab-1254.
Radial Stresses in Concrete.
N
S
Unit Stresses in 1000 lbs.
40
30
20
10
0
100,000
80,000
60,000
30,000
C
B
A
3
2
1
Inches
40
30
20
10
0
10
20
30
40




W
Slab-1254
Radial Stresses in Concrete.
E
40
30
20
10
0
Unit Stresses in 1000 lbs.
100000
80000
60000
30000
C
B
3
A 2
1
A 2
3
B
C
Inches
40
30
20
10
0
10
20
30
40
66

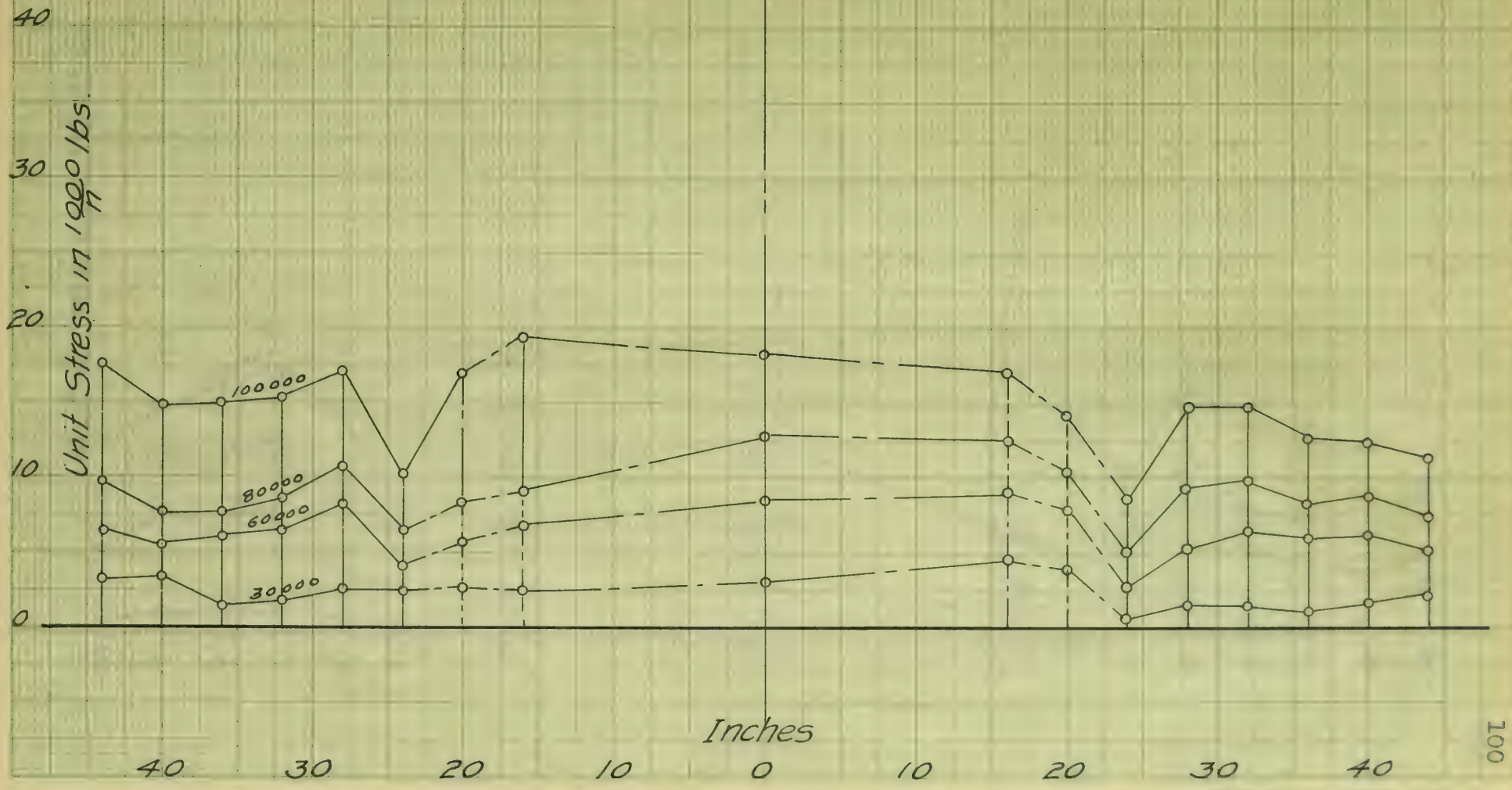


S-W

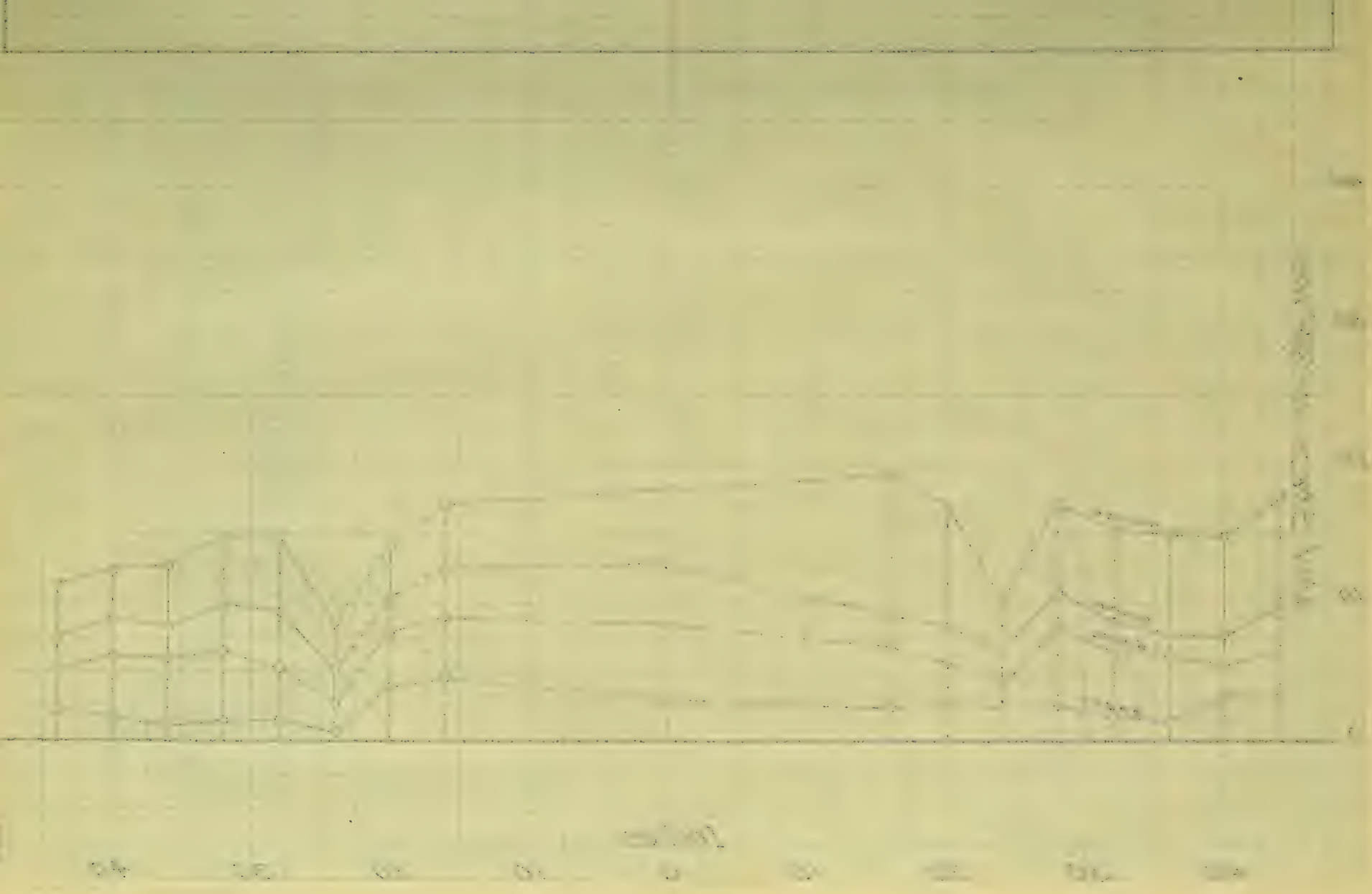
SLAB 1254

N-E

Average Circumferential Deformations in Concrete



100

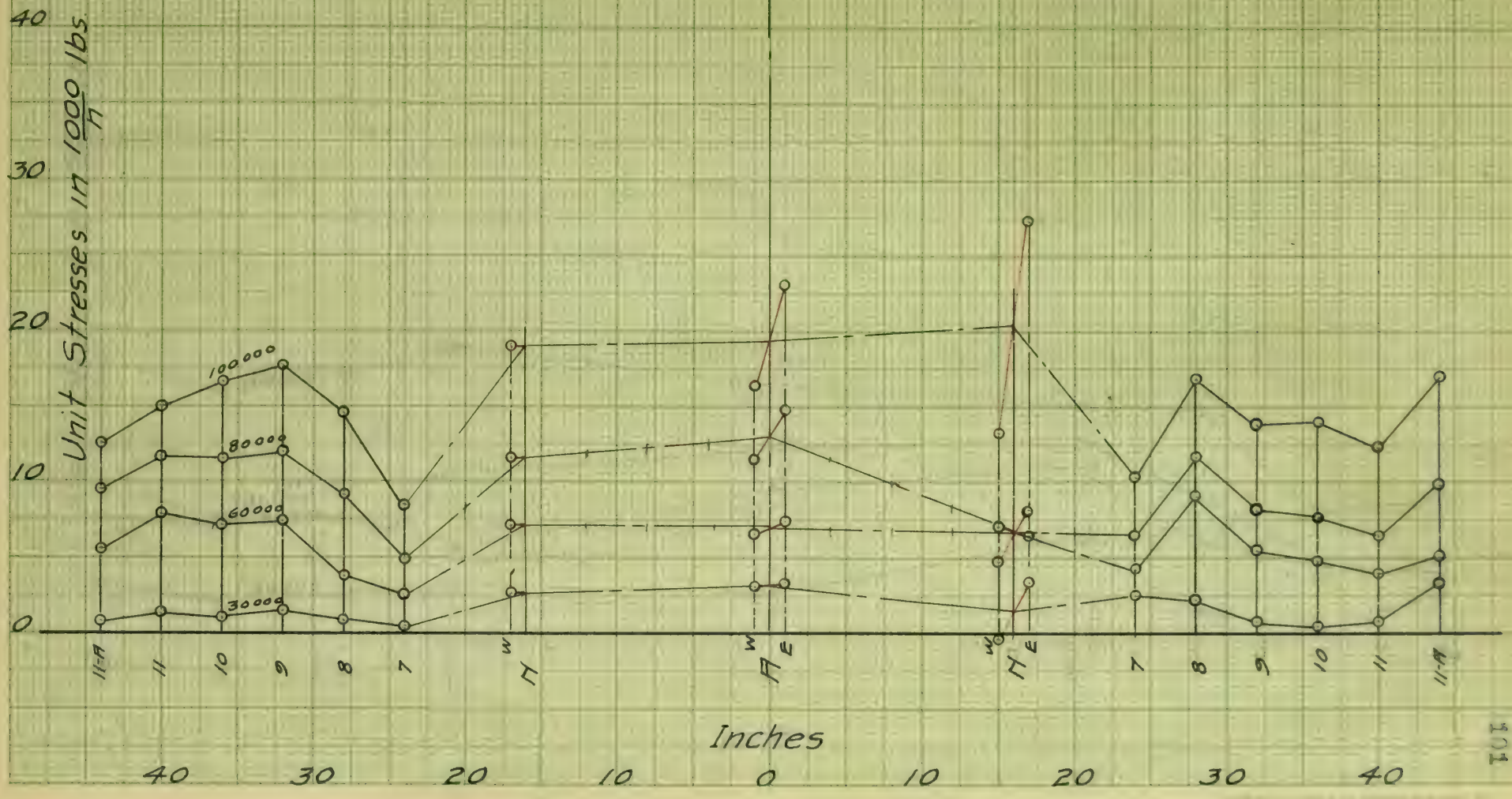


N

S

Slab-1254

Circumferential Stresses in Concrete.



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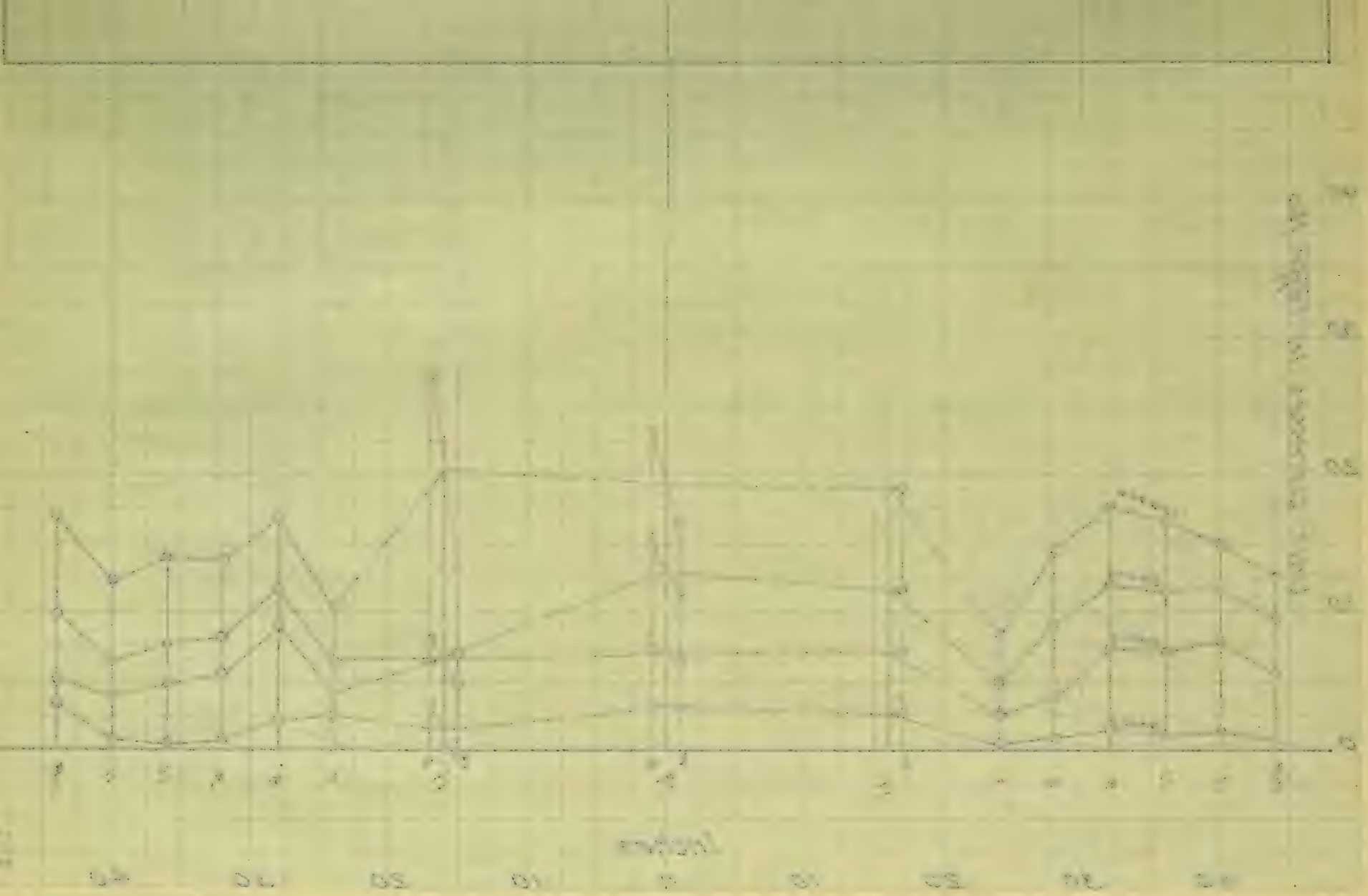
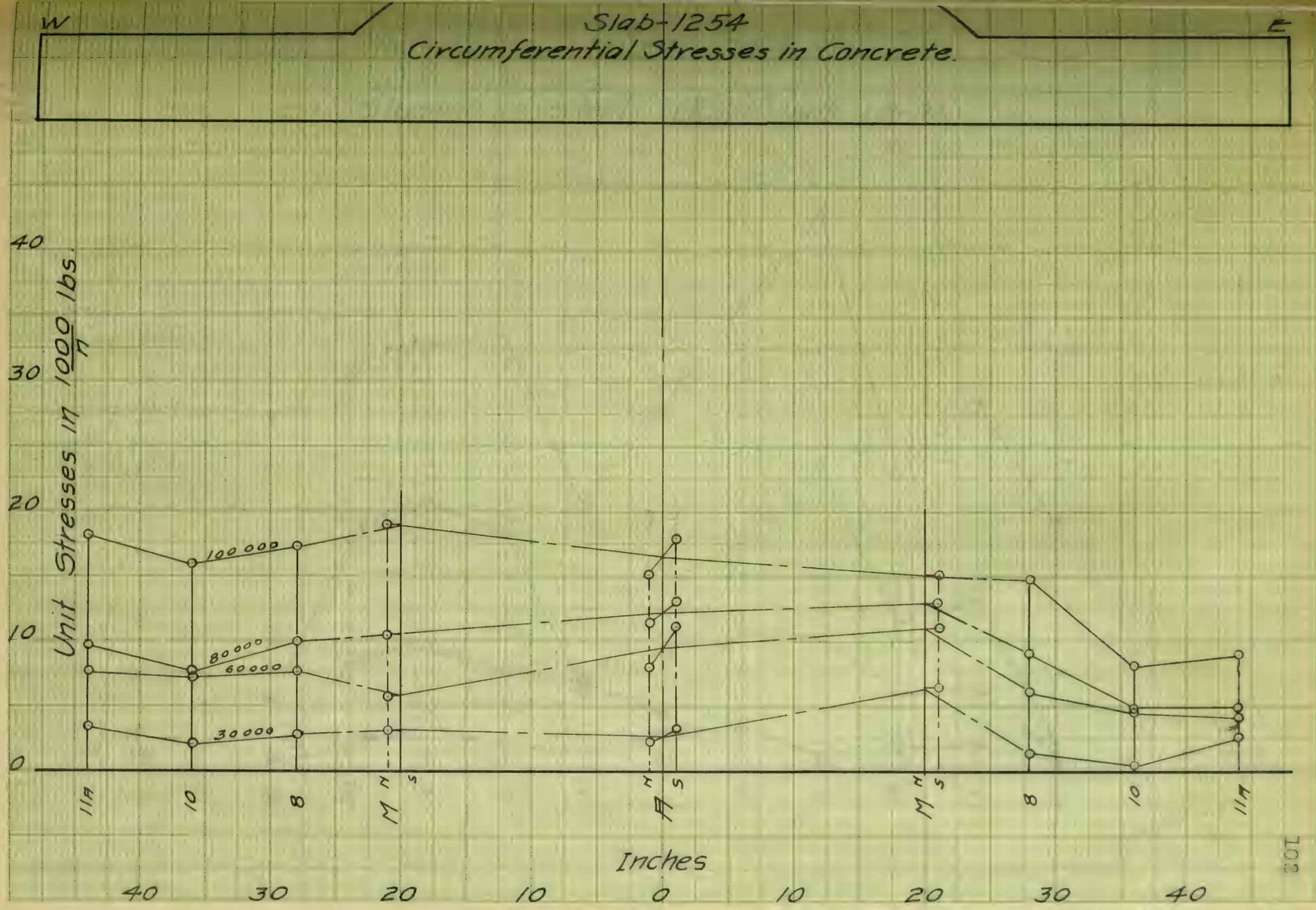
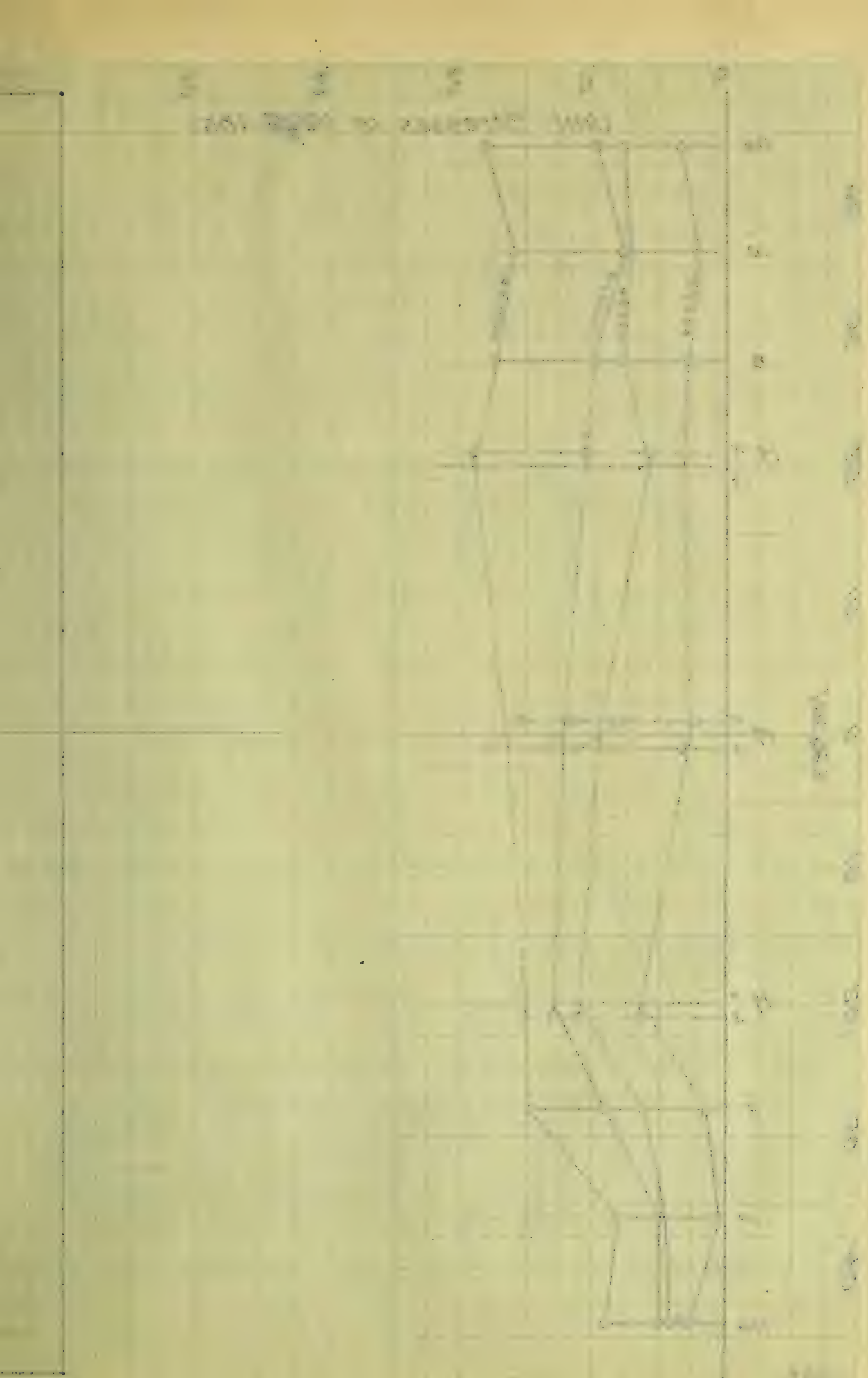
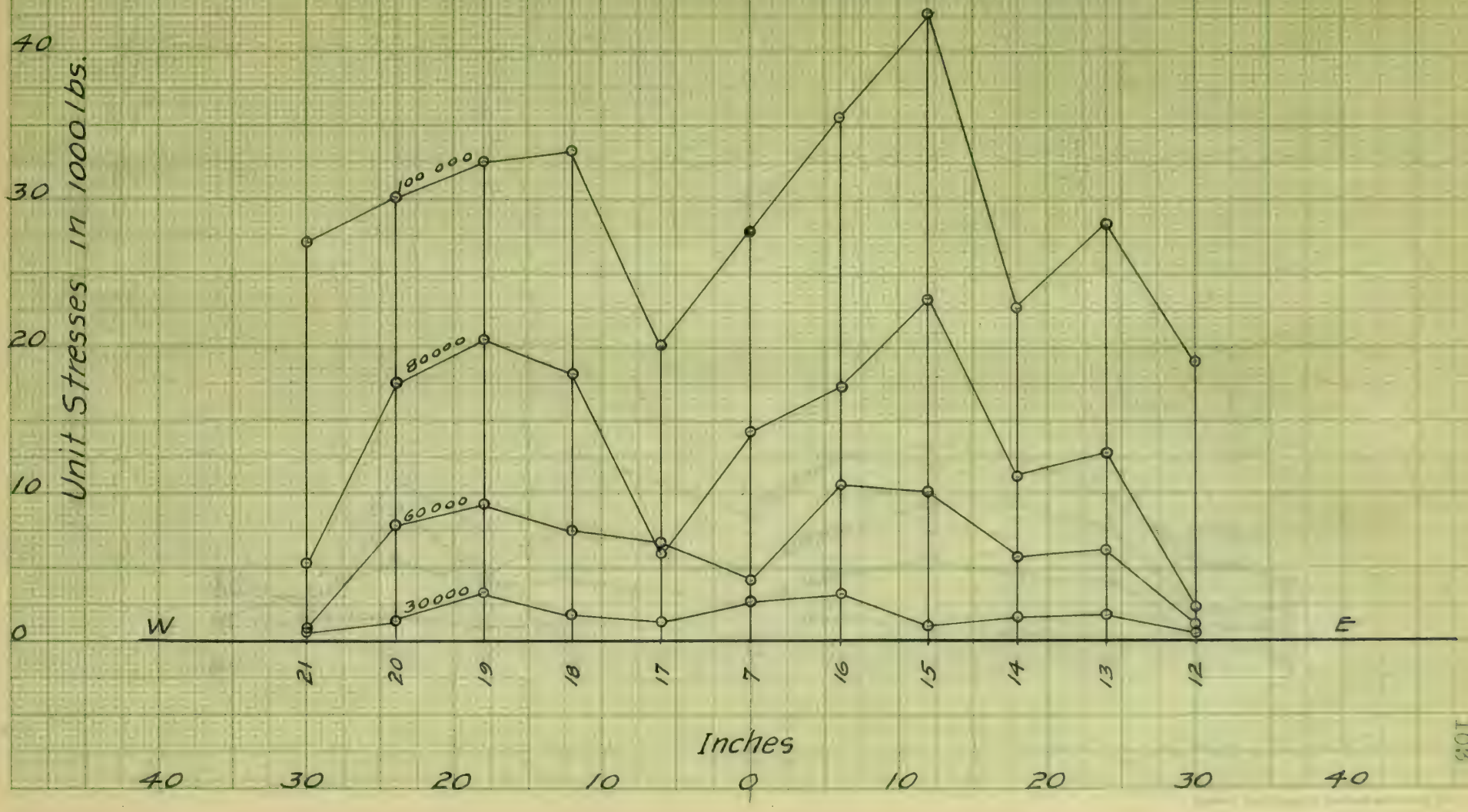


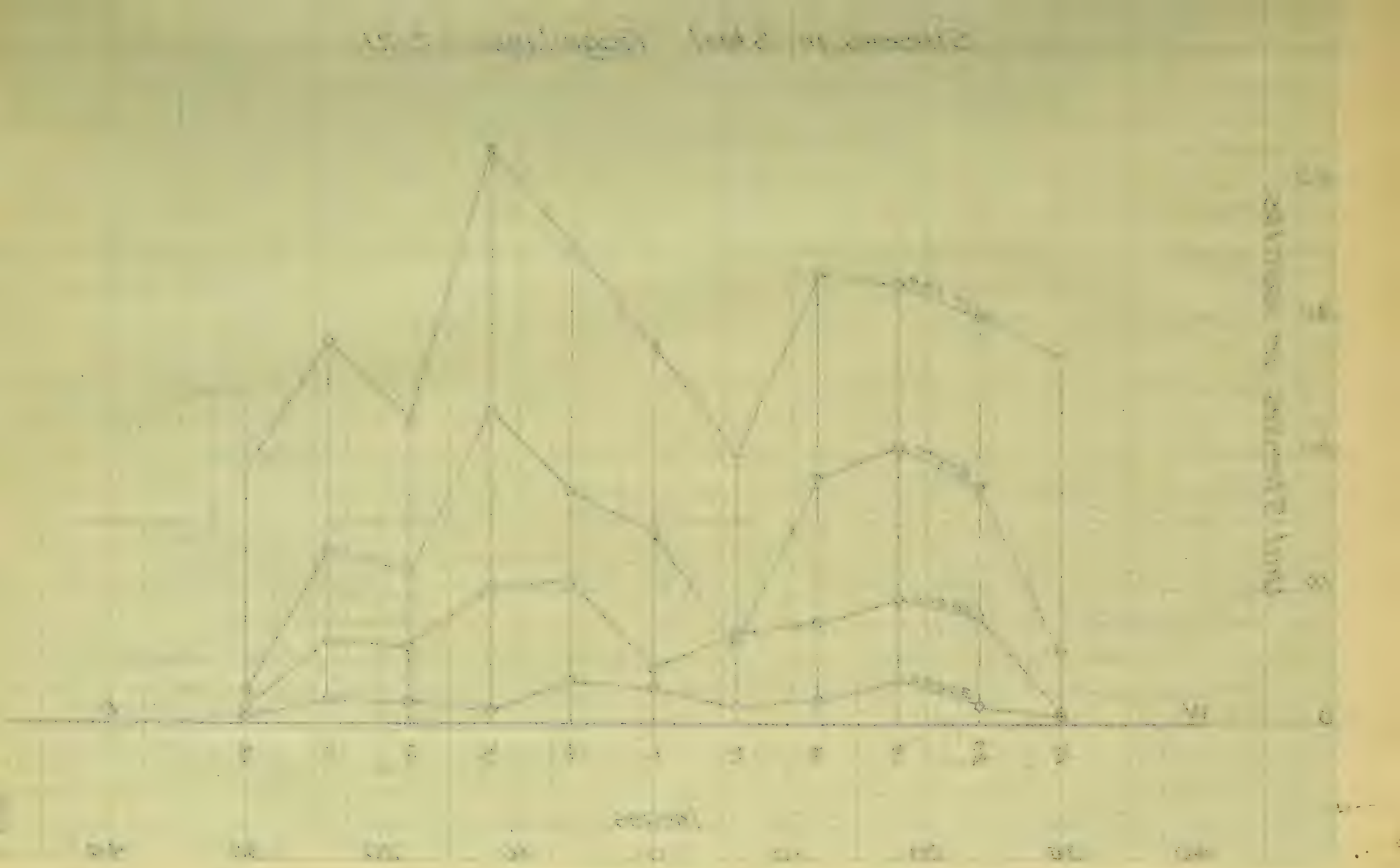

W
Slab-1254
Circumferential Stresses in Concrete.
E
40
30
20
10
0
Unit Stresses in 1000 lbs.
100 000
80000
60000
30000
11A
10
8
M
N
S
Inches
40
30
20
10
0
10
20
30
40



SLAB 1254

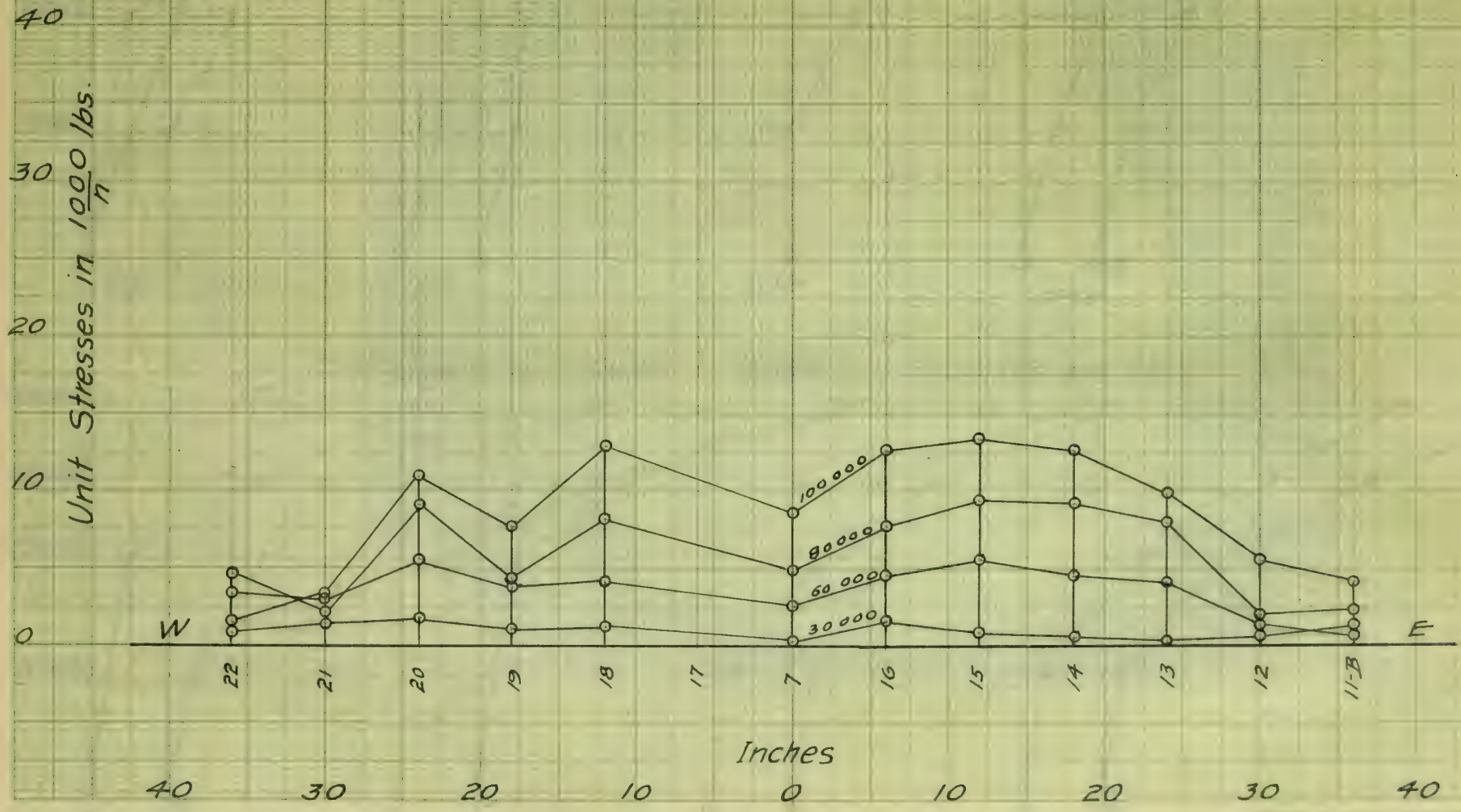
Stresses in Steel Gage Lines 12-21

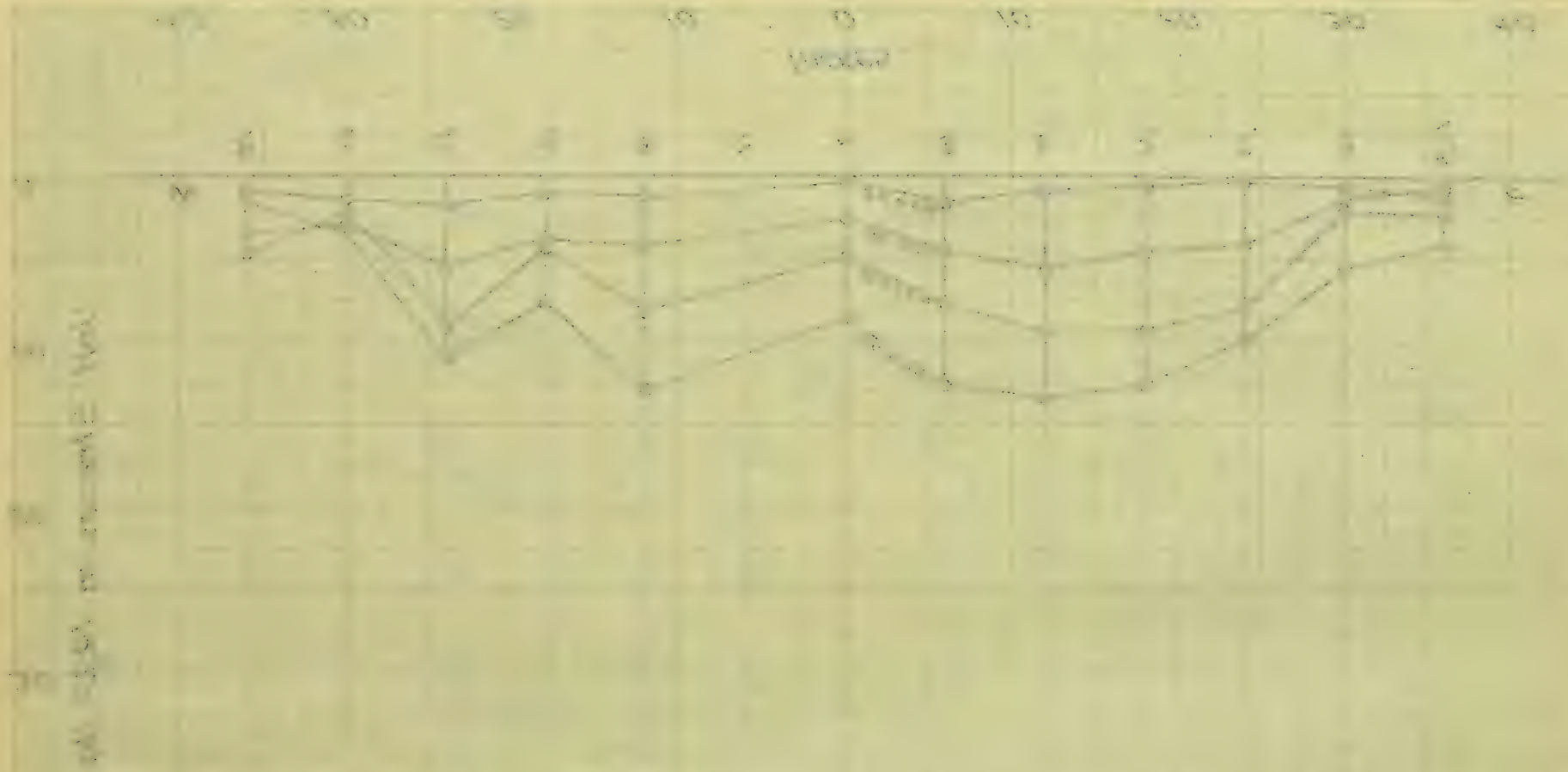




SLAB 1254

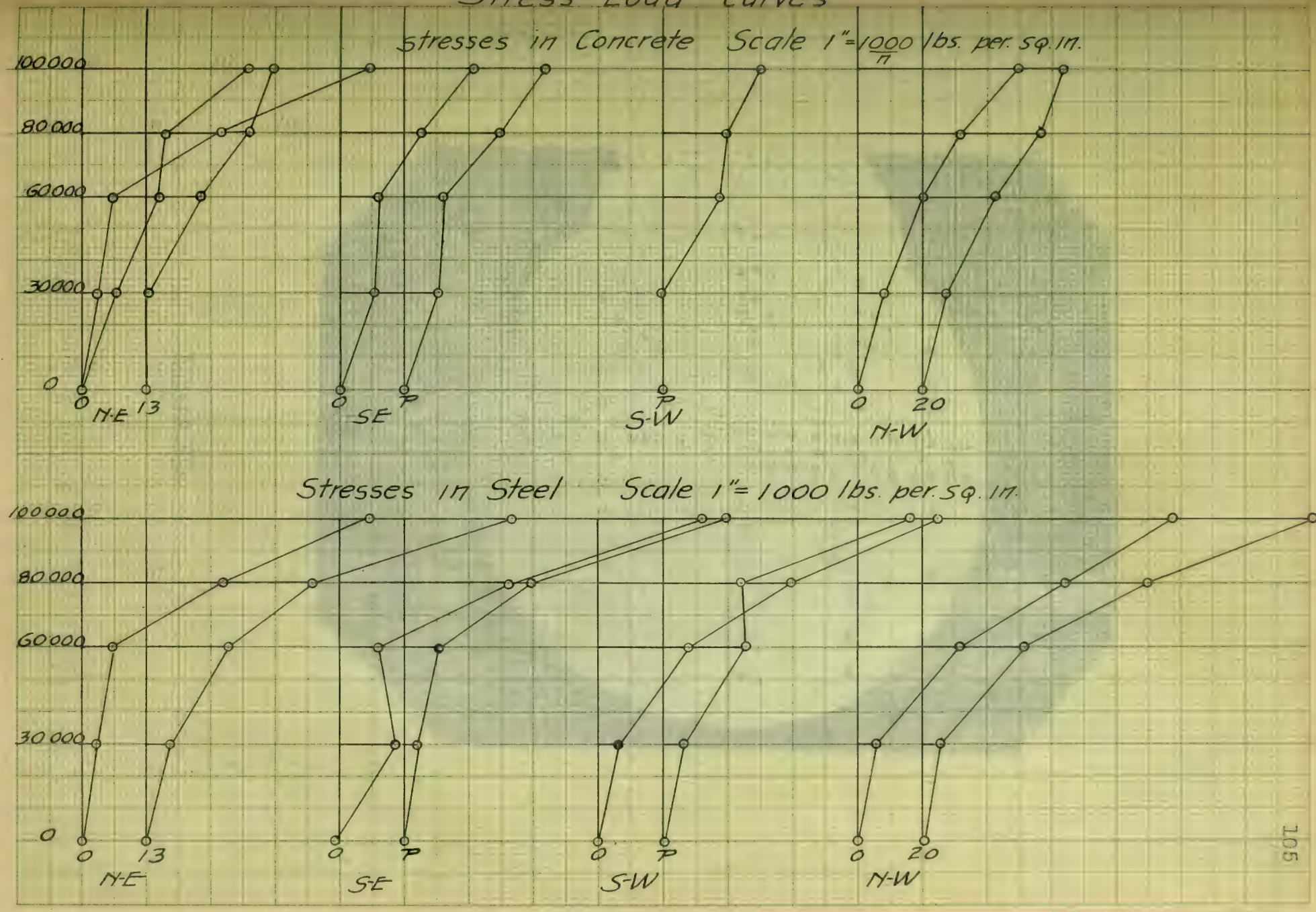
Stresses in Concrete Gage Lines 11B-21





SLAB 1234

Stress-Load Curves



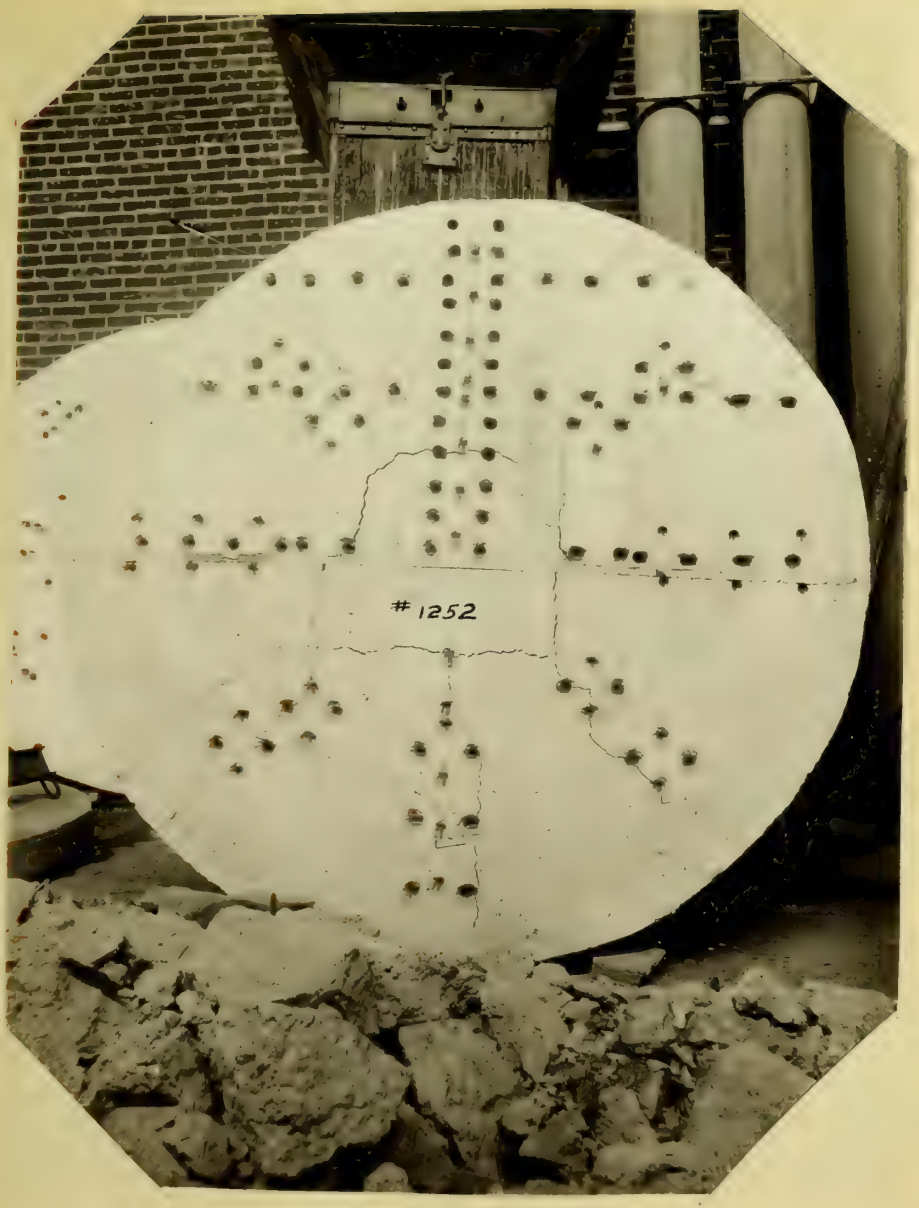


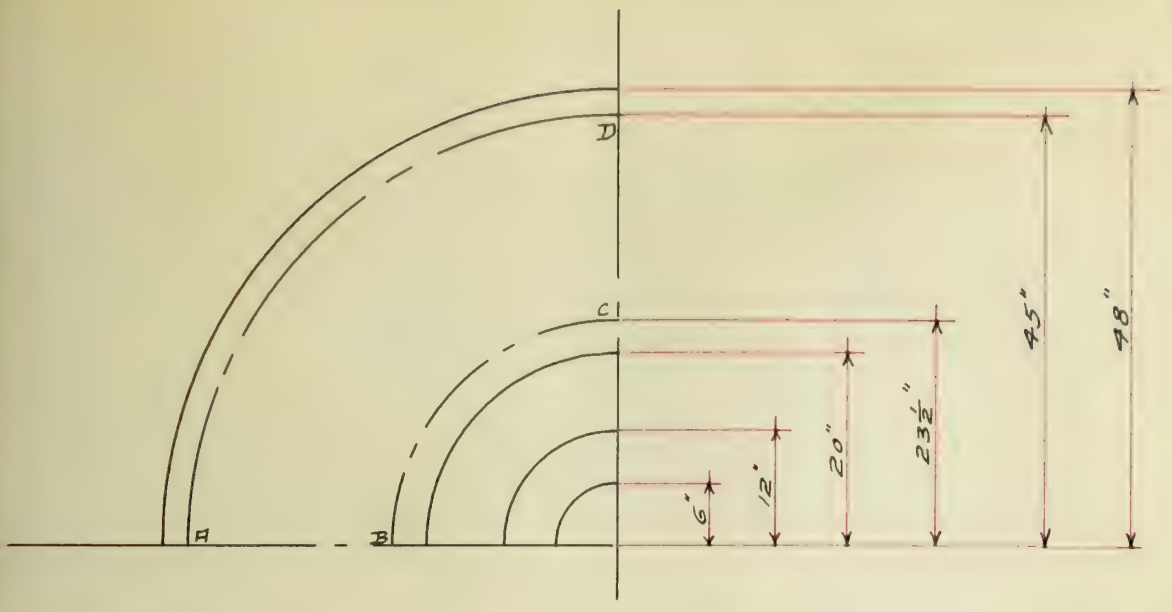
Figure 21.

VIEW OF WALL # 1252 AFTER TESTING.

D. Slab with Rectangular Reinforcement, 24 inch or Diameter and 2 inch drop.

20. Phenomena of Tests. Slab 1251 was the only slab corresponding to the above description and the only difference between it and slab 1251 is the 2 inch drop. This slab carried only an ultimate of 71000 pounds or about 7000 pounds more than the maximum load of slab 1251. It also had both an ultimate and a primary failure which was due to the exceeding of the tensile strength in the steel. Cracks appeared at about the same load as for slab 1251 and were practically the same in appearance. One very noticeable thing in regard to this test was that at the ultimate load the drop sheared entirely off of the slab. This would indicate that in flat slab construction the horizontal shear is a thing which should recieve consideration.

21. Load Deformation Relations. In this test much trouble was had with poorly set plugs in the concrete and as a result some of the concrete curves are not very good. Also the readings were taken on two different days and although the same standard bar and instruments were used, readings on the steel which were taken on the steel the first day and repeated the second day, showed a difference of about 3000 pounds per sq. in. in the steel stresses. The indication seems to be that for some reason the stresses in the steel for the higher loads are 3000 lbs. too high ~~and~~ and this correction is made in finding the equilibrium of the steel stresses with the bending moment, although it is not made on the data sheets or on the curves.



Slab 1252.

Equilibrium Calculations.

The bending moment equals $.707\left(\frac{45-23\frac{1}{2}}{4}\right)60000$ or 228000 inch pounds in the direction CD on the section ABC. (f_s=60000#)

11½-7/16 inch diam. rods cut the section.

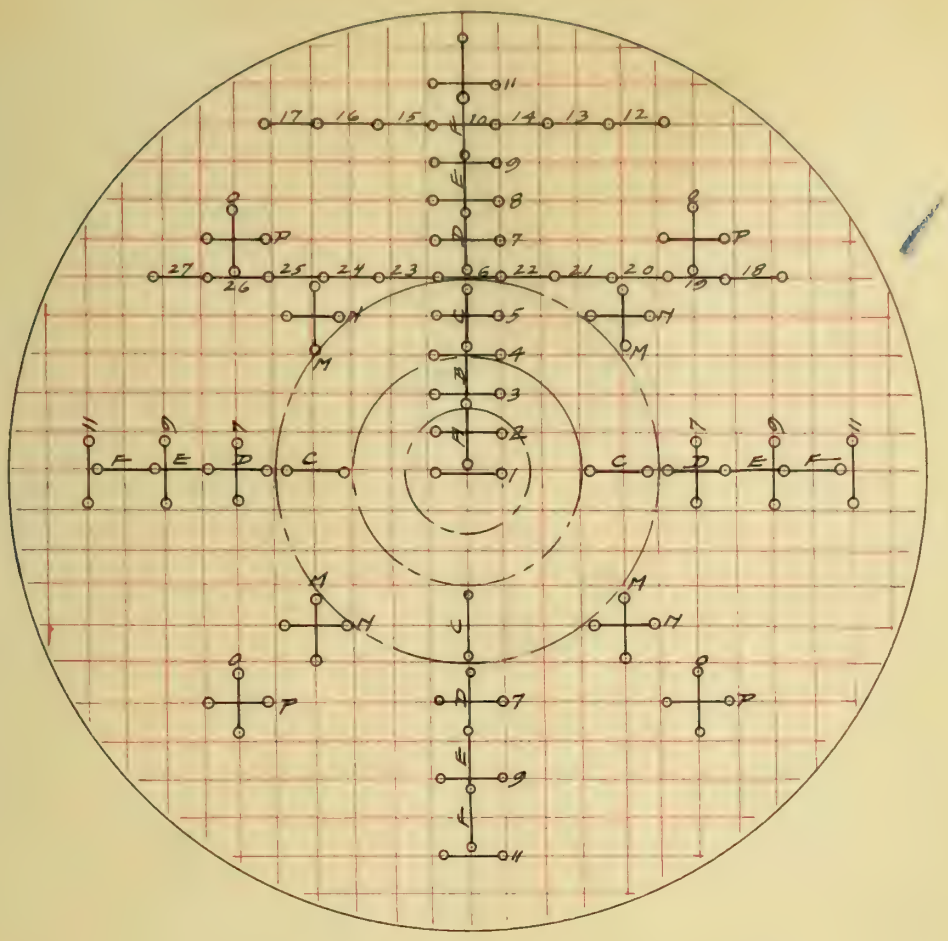
A_s equals 1.73 sq. inches.

The average steel stress for a load of 60000 pounds equals 29500 pounds per sq. inch on all the rods cutting the section ABC in the direction CD.

Therefore the effective depth becomes

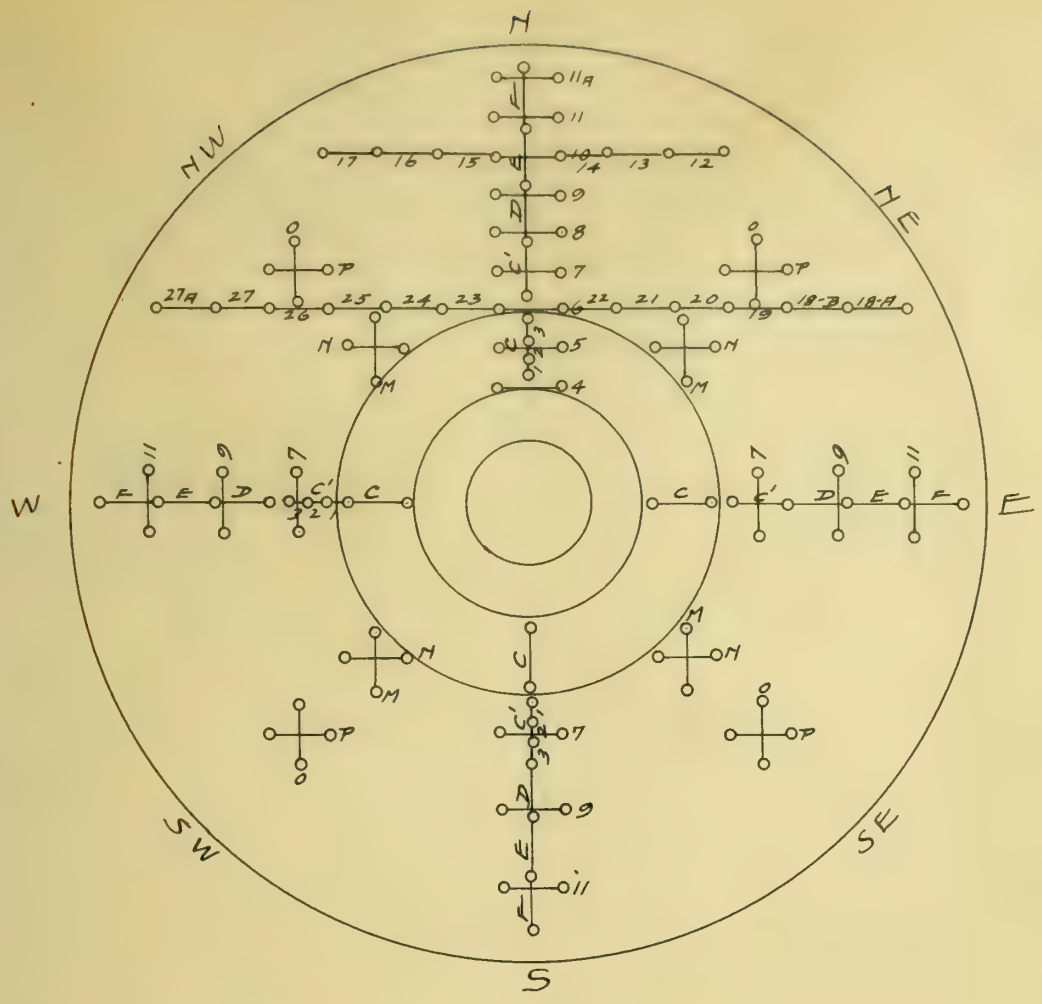
228000/1.73(29500) or 4.47 inches.

If we make allowance for the probable error in the steel readings, the steel stress becomes about 26500 pounds per sq. inch and the value of jD becomes 4.97 inches.



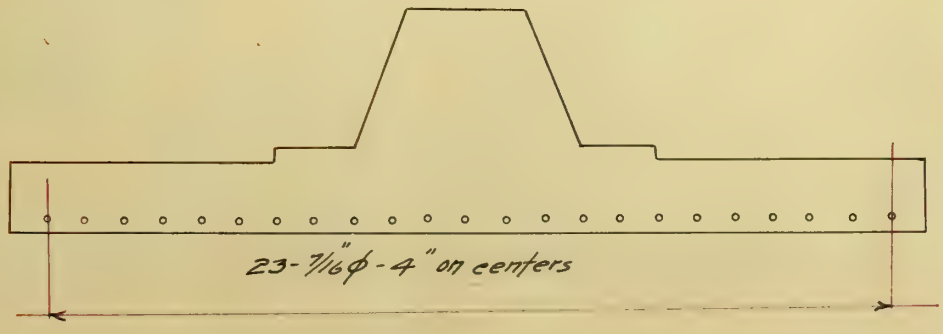
Cage Lines in the Steel. Slab 1252 .

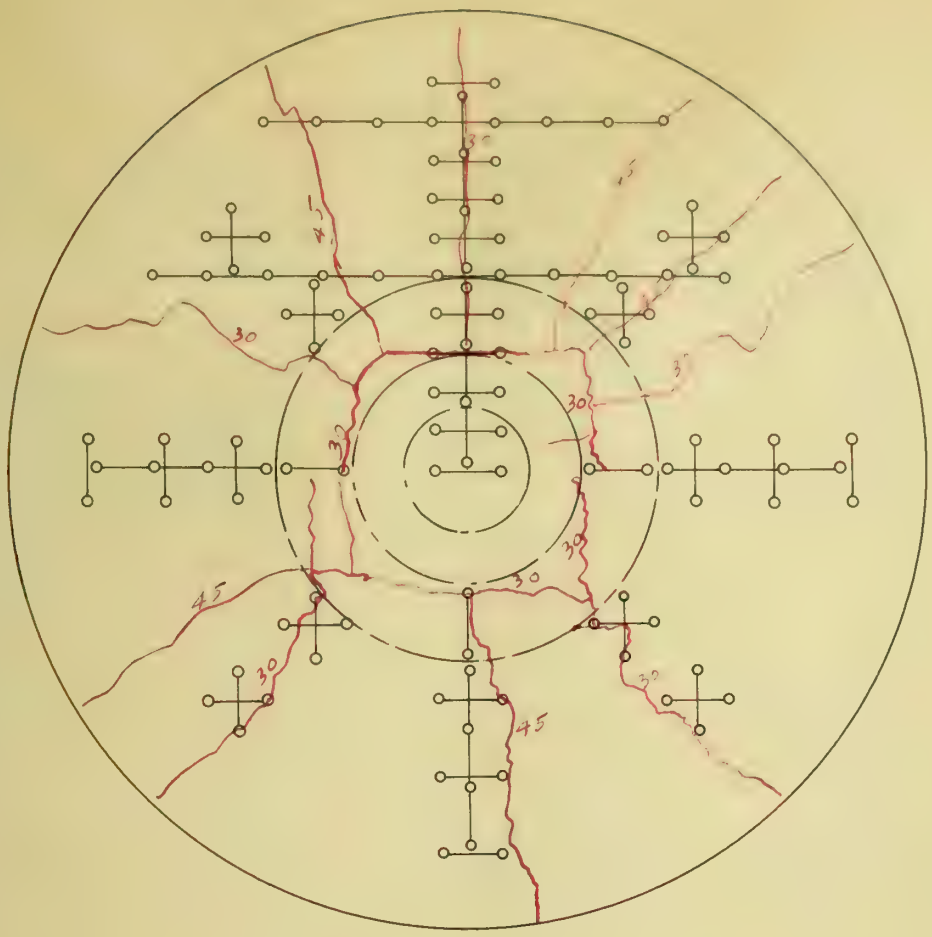
Figure 22.



Gage Lines in the Concrete. Slab 1252.

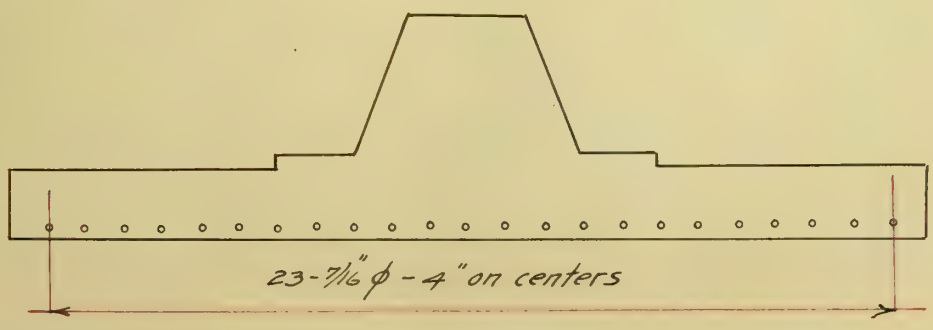
Figure 23.

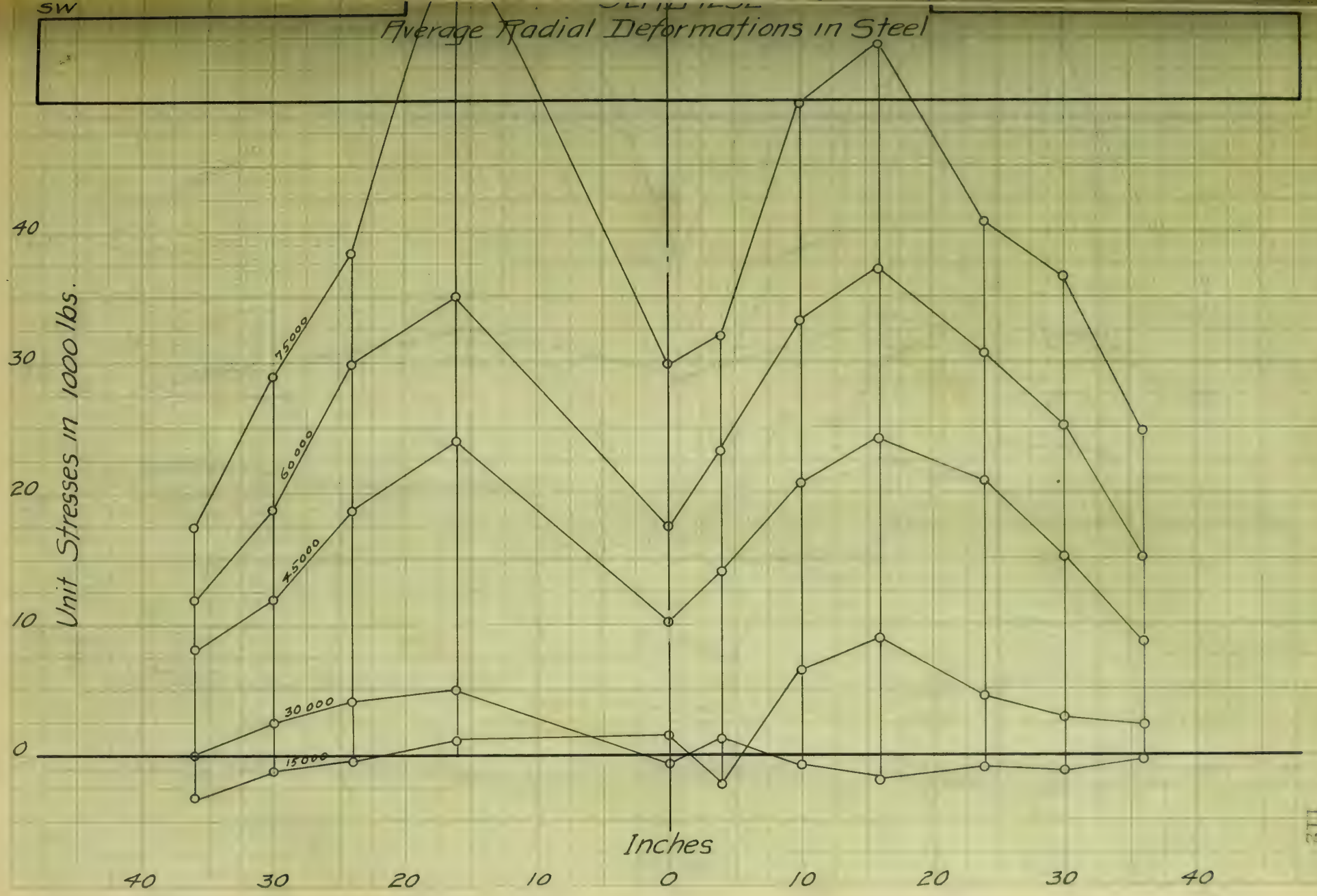


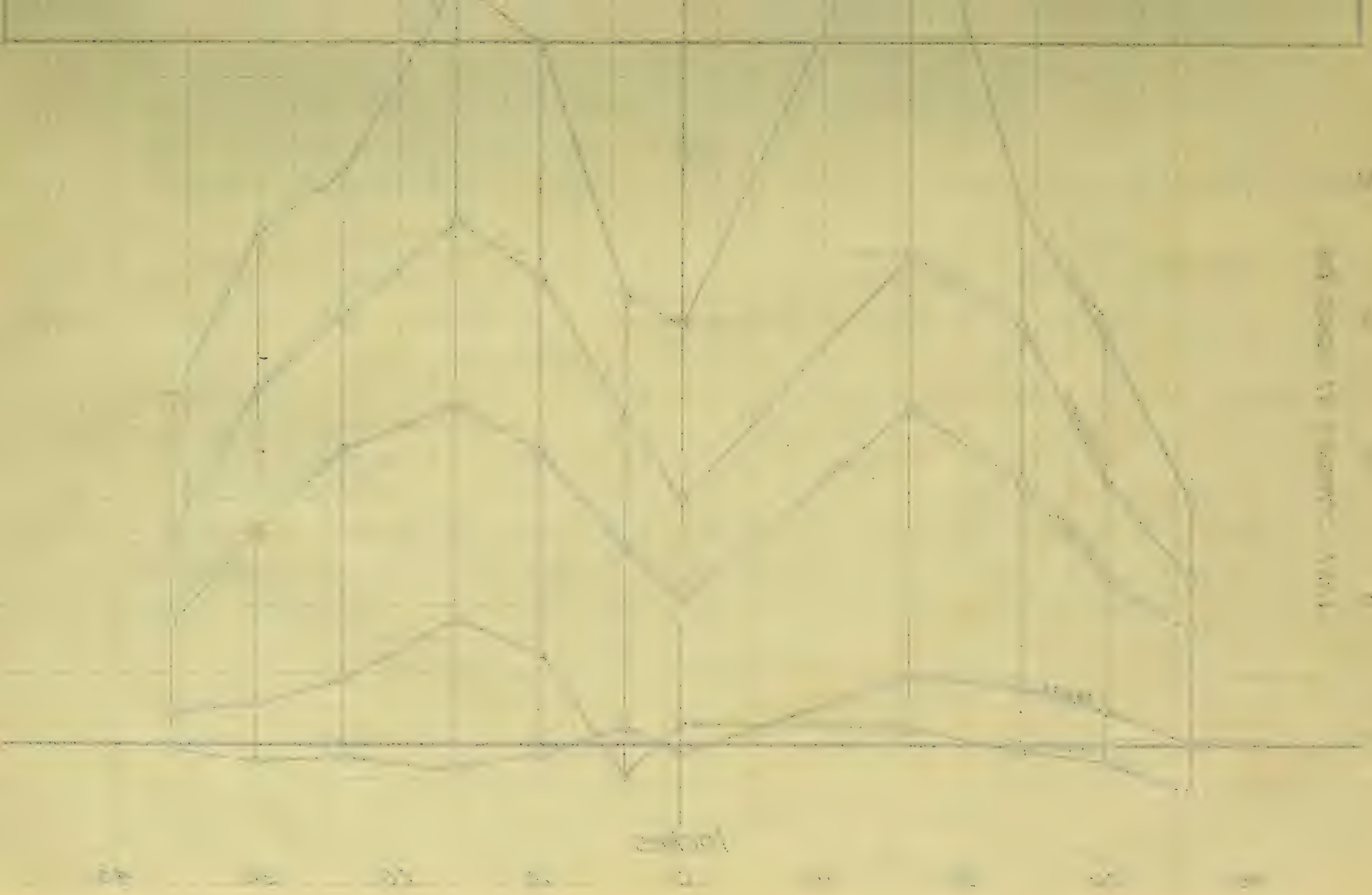


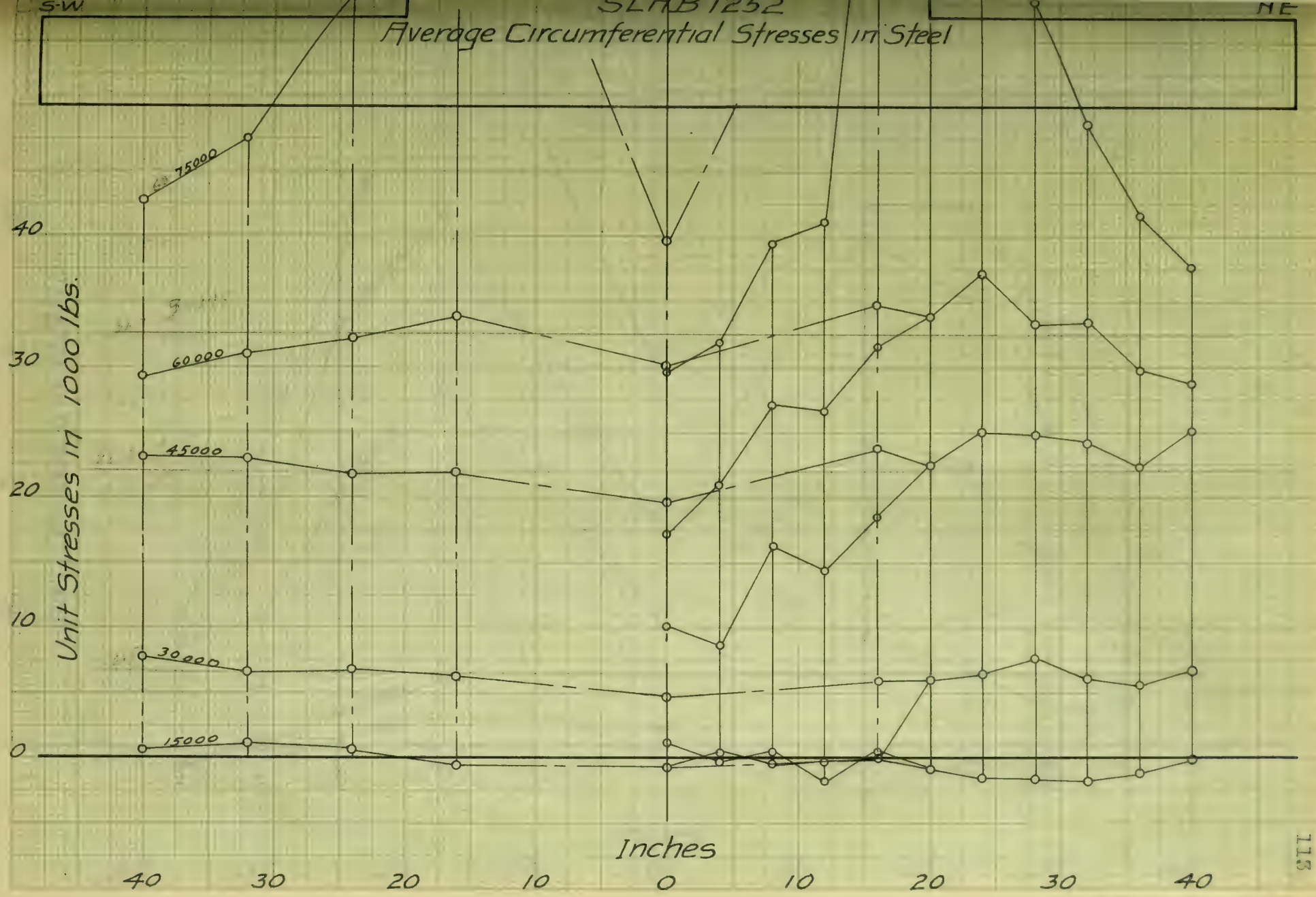
Sketch of Cracks. Slab 1252.

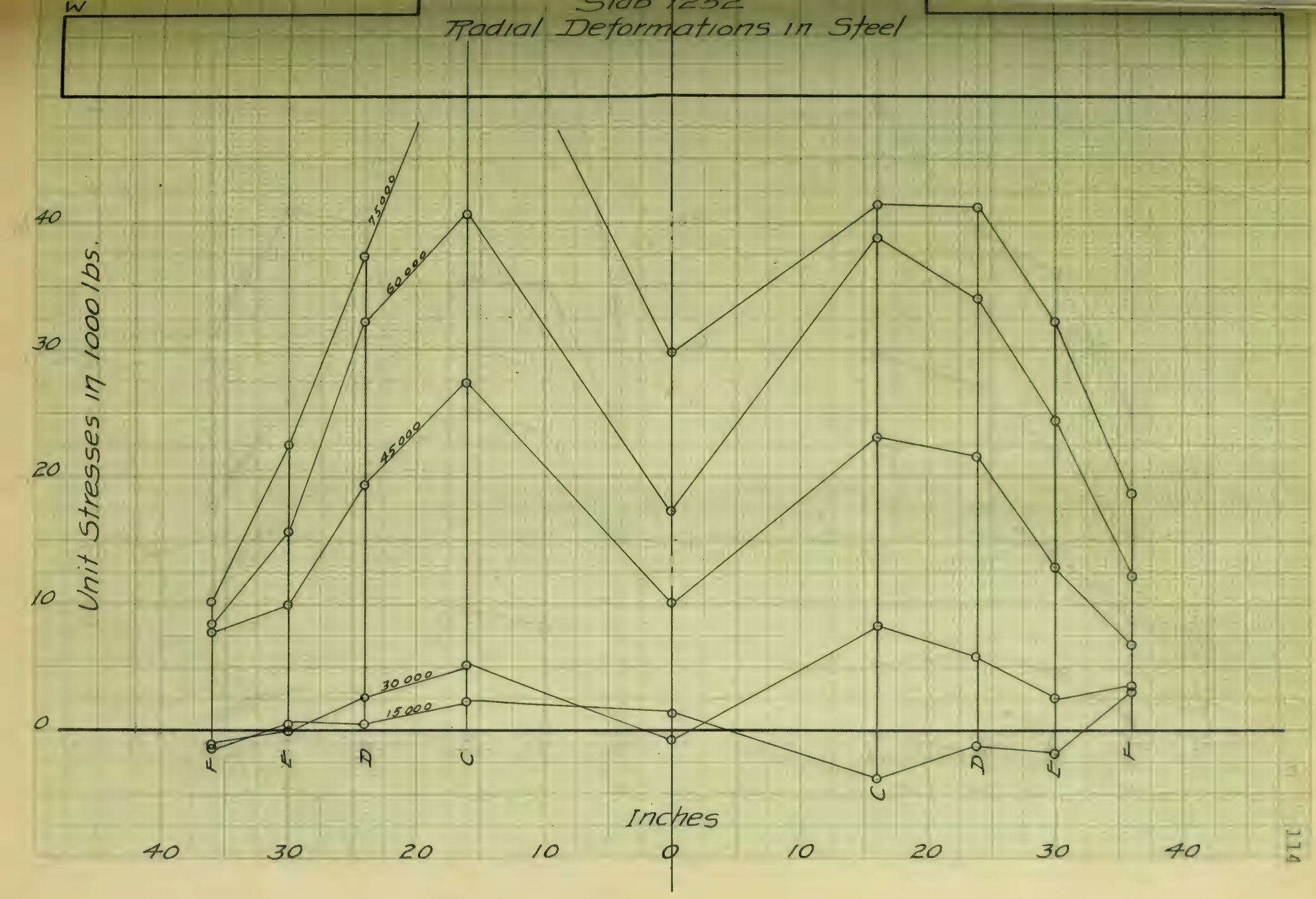
Figure 24.




SW
Average Radial Deformations in Steel
40
30
20
10
0
Unit Stresses in 1000 lbs.
75000
60000
45000
30000
15000
Inches
40
30
20
10
0
10
20
30
40

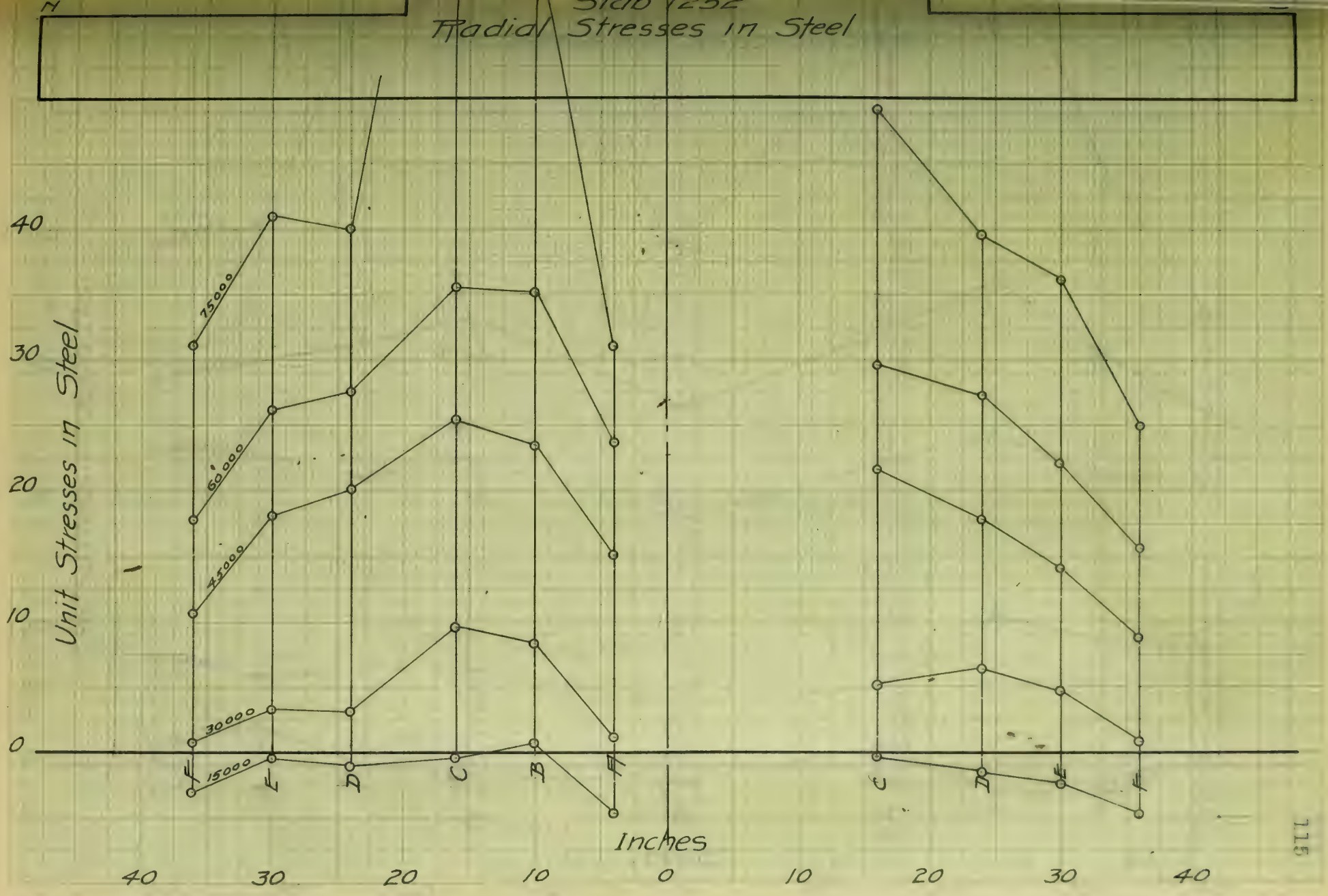


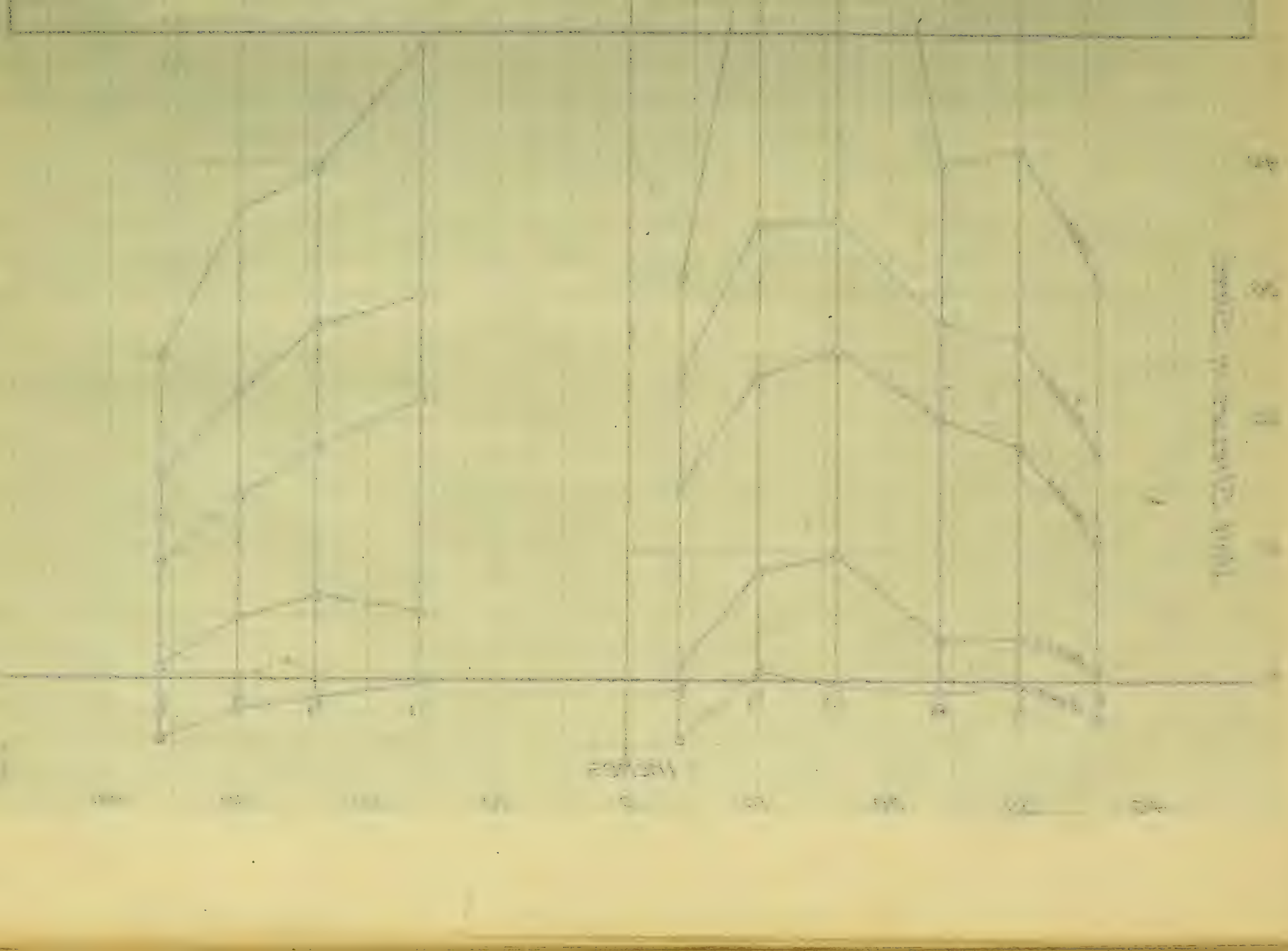

SLAB 1232
Average Circumferential Stresses in Steel
S-W
NE
75000
60000
45000
30000
15000
Unit Stresses in 1000 lbs.
40
30
20
10
0
Inches
40
30
20
10
0
10
20
30
40

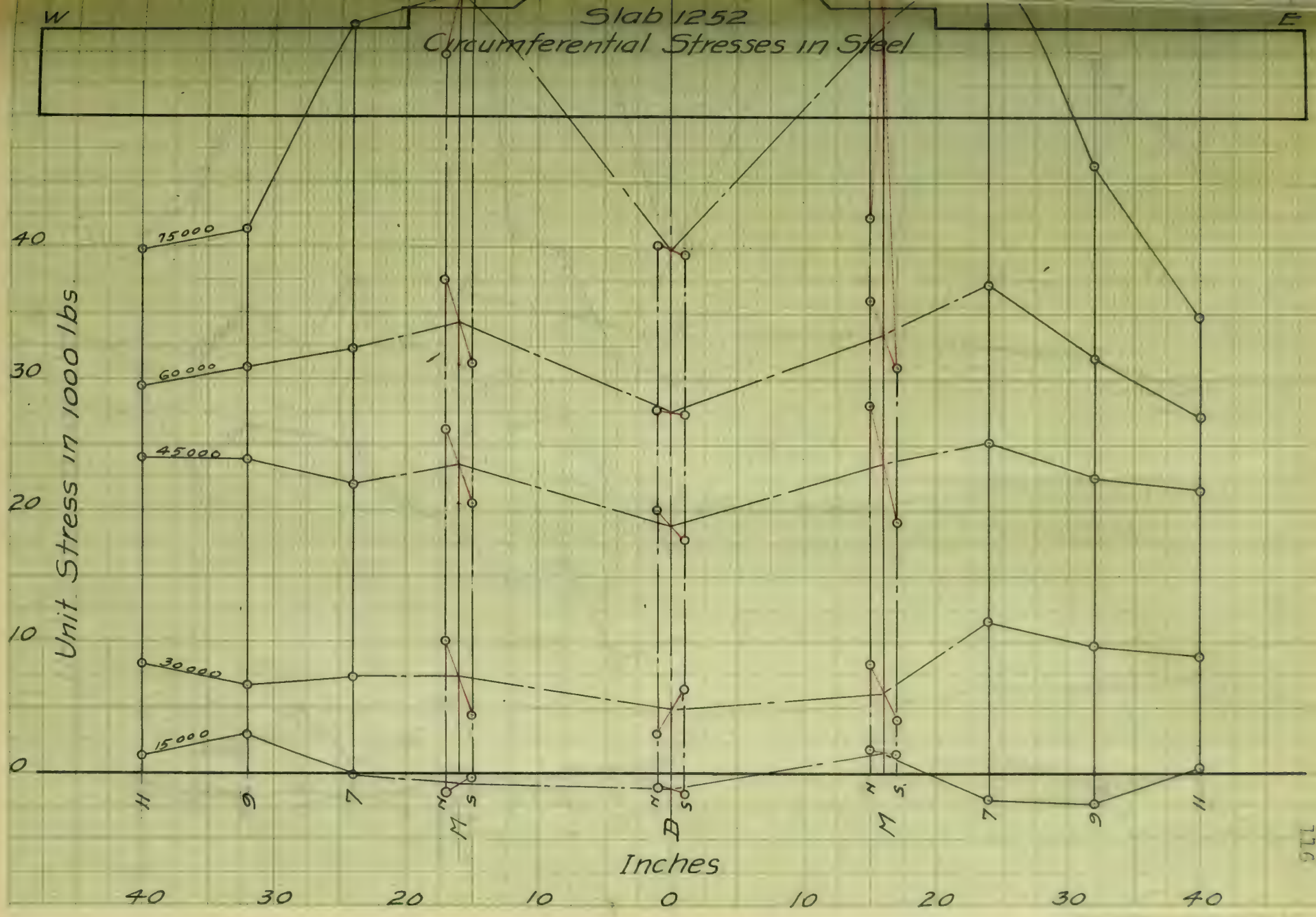

W
Slab 1232
Radial Deformations in Steel
Unit Stresses in 1000 lbs.
40
30
20
10
0
75000
60000
45000
30000
15000
F
E
D
C
C
D
E
F
Inches
40
30
20
10
0
10
20
30
40

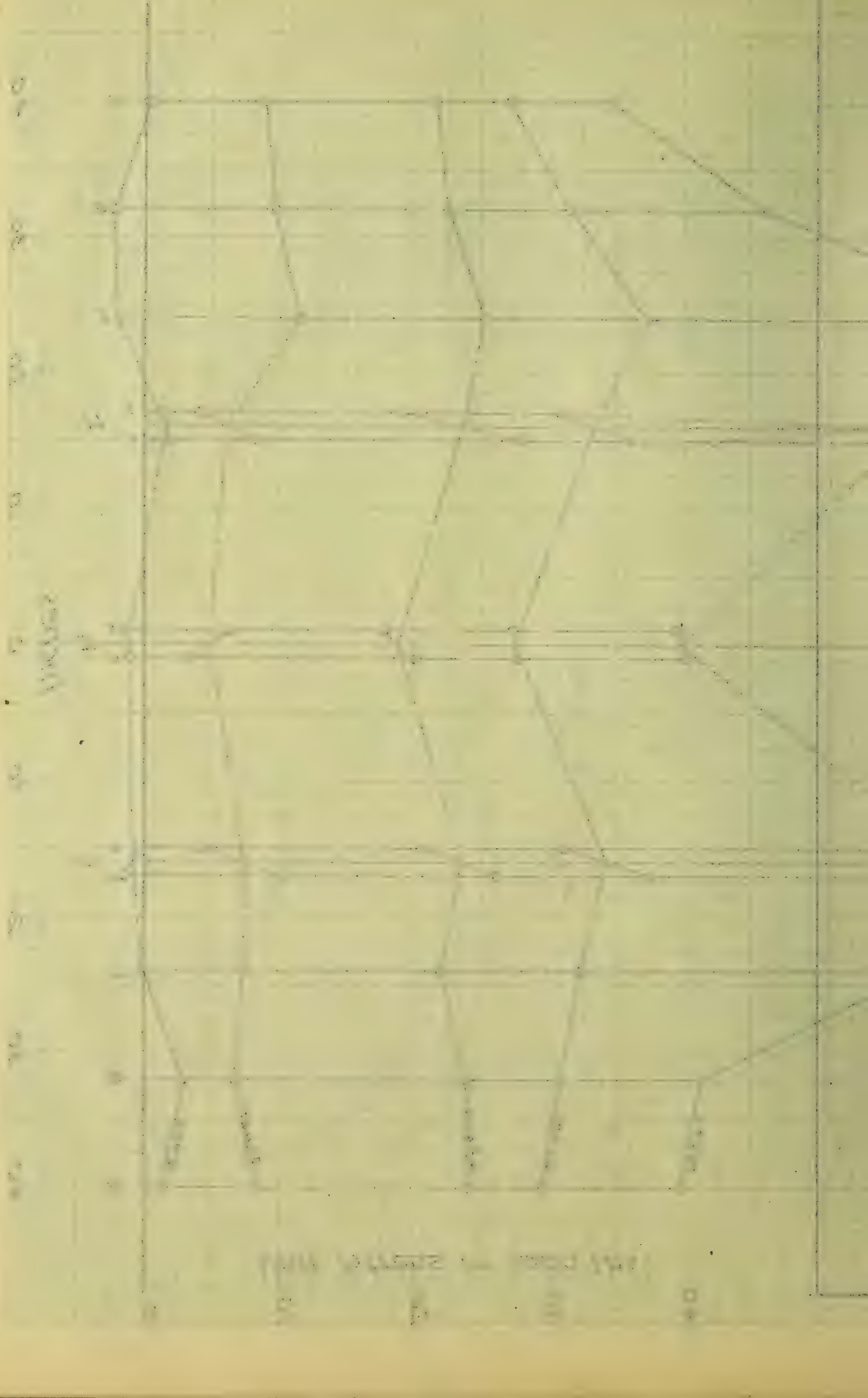
Slab 1252

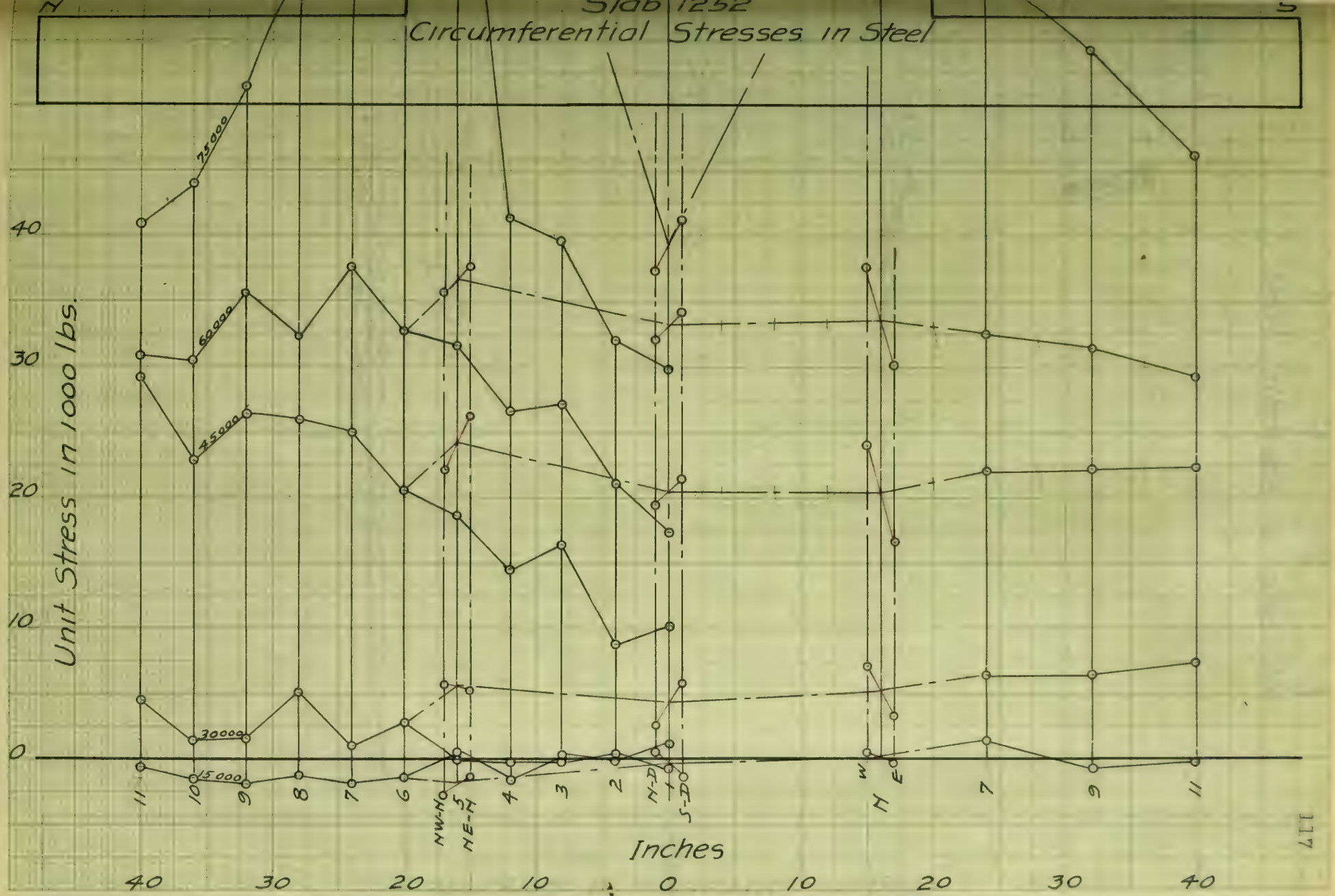
Radial Stresses in Steel

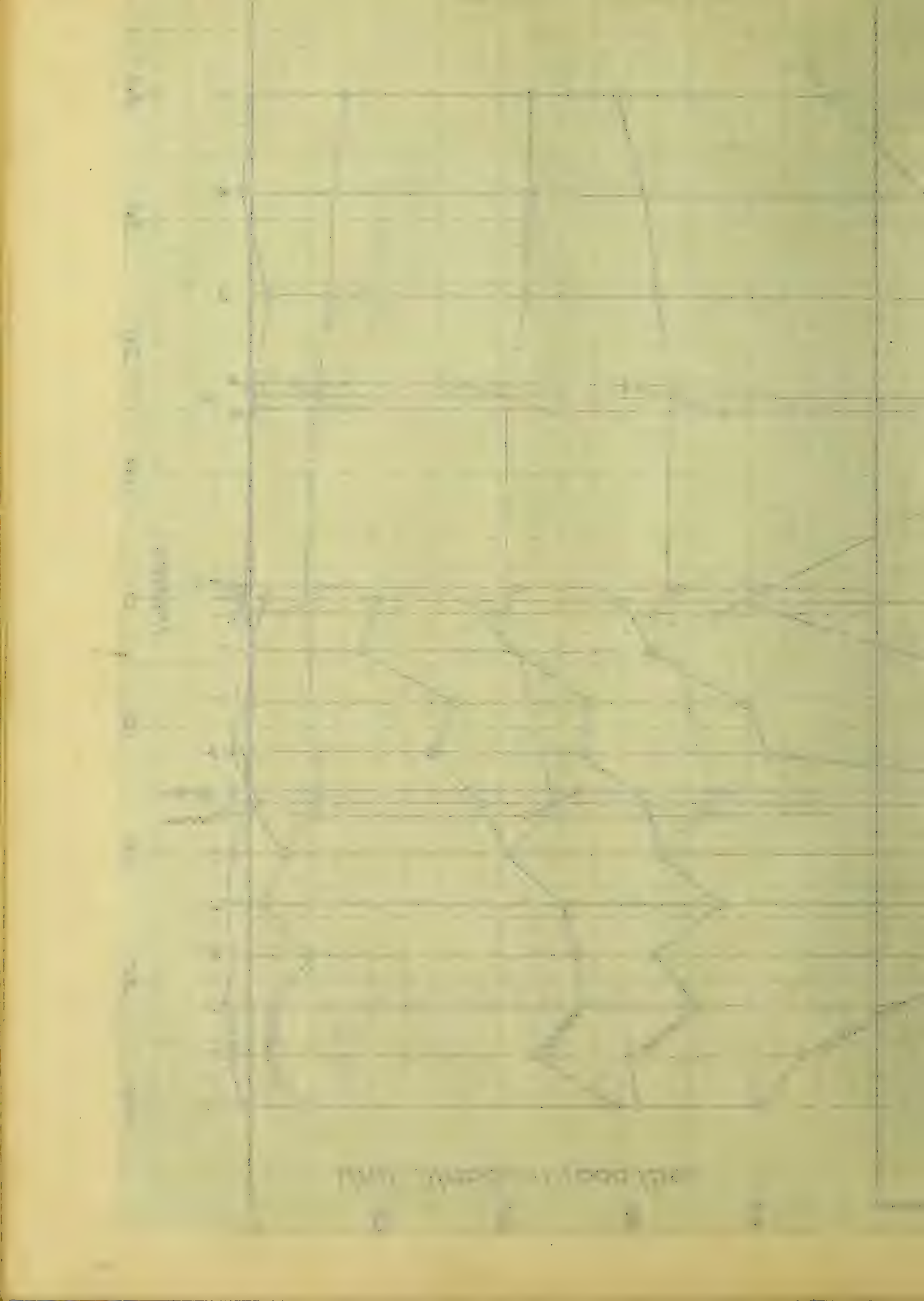


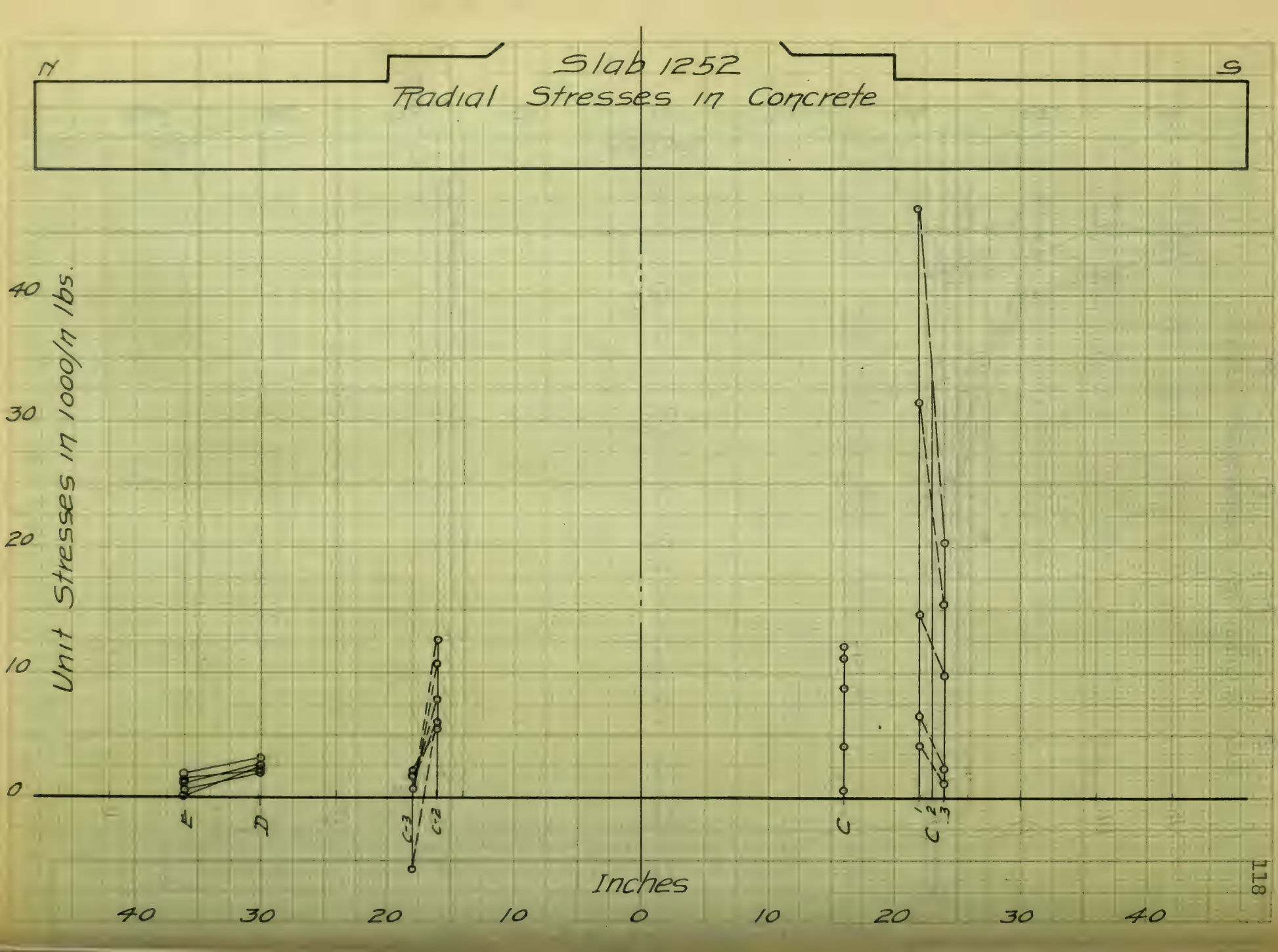


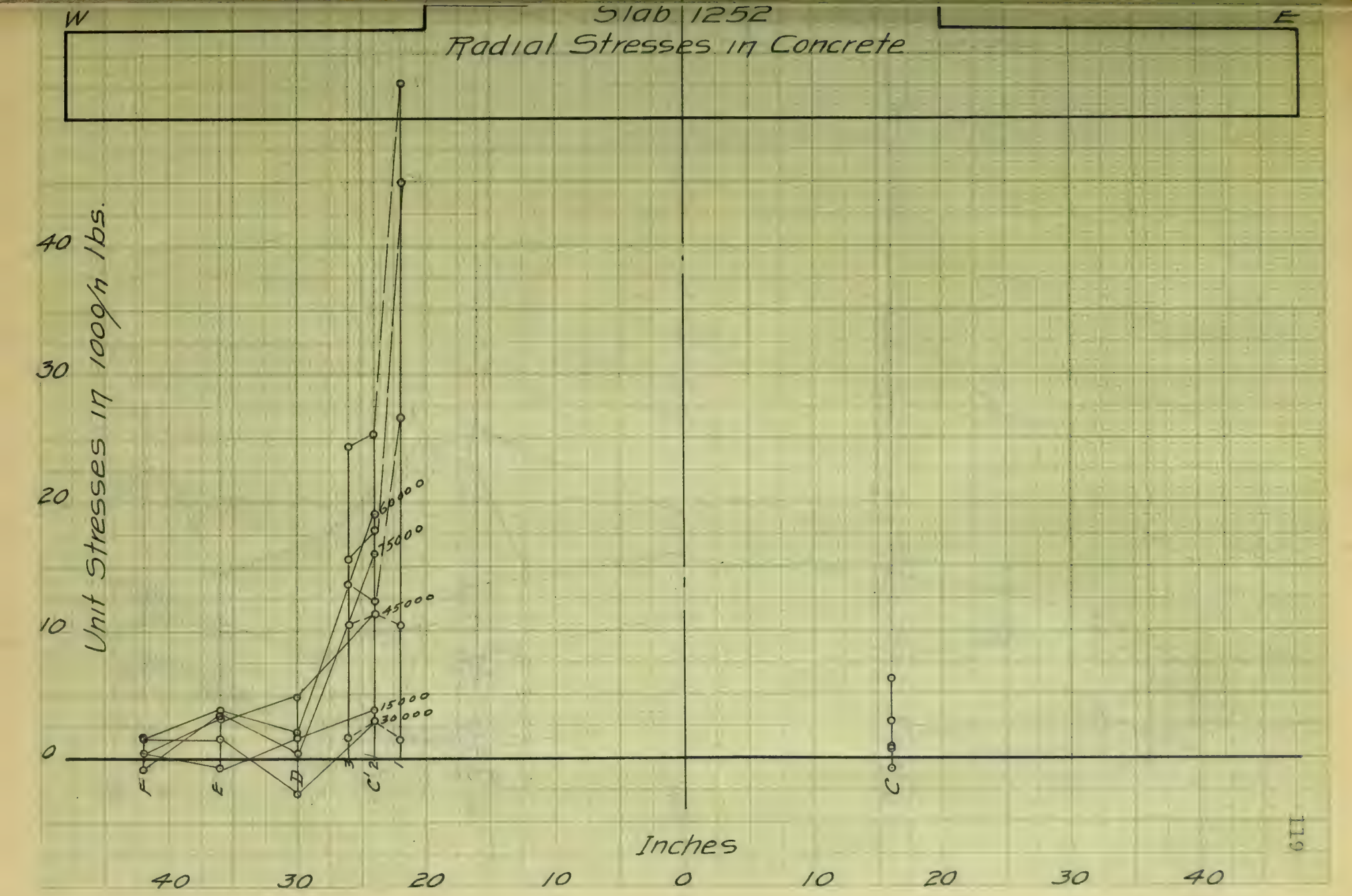

W
E
Slab 1252
Circumferential Stresses in Steel
Unit Stress in 1000 lbs.
40
30
20
10
0
75000
60000
45000
30000
15000
11
9
7
M
N
S
D
N
S
M
N
S
7
9
11
Inches
40
30
20
10
0
10
20
30
40

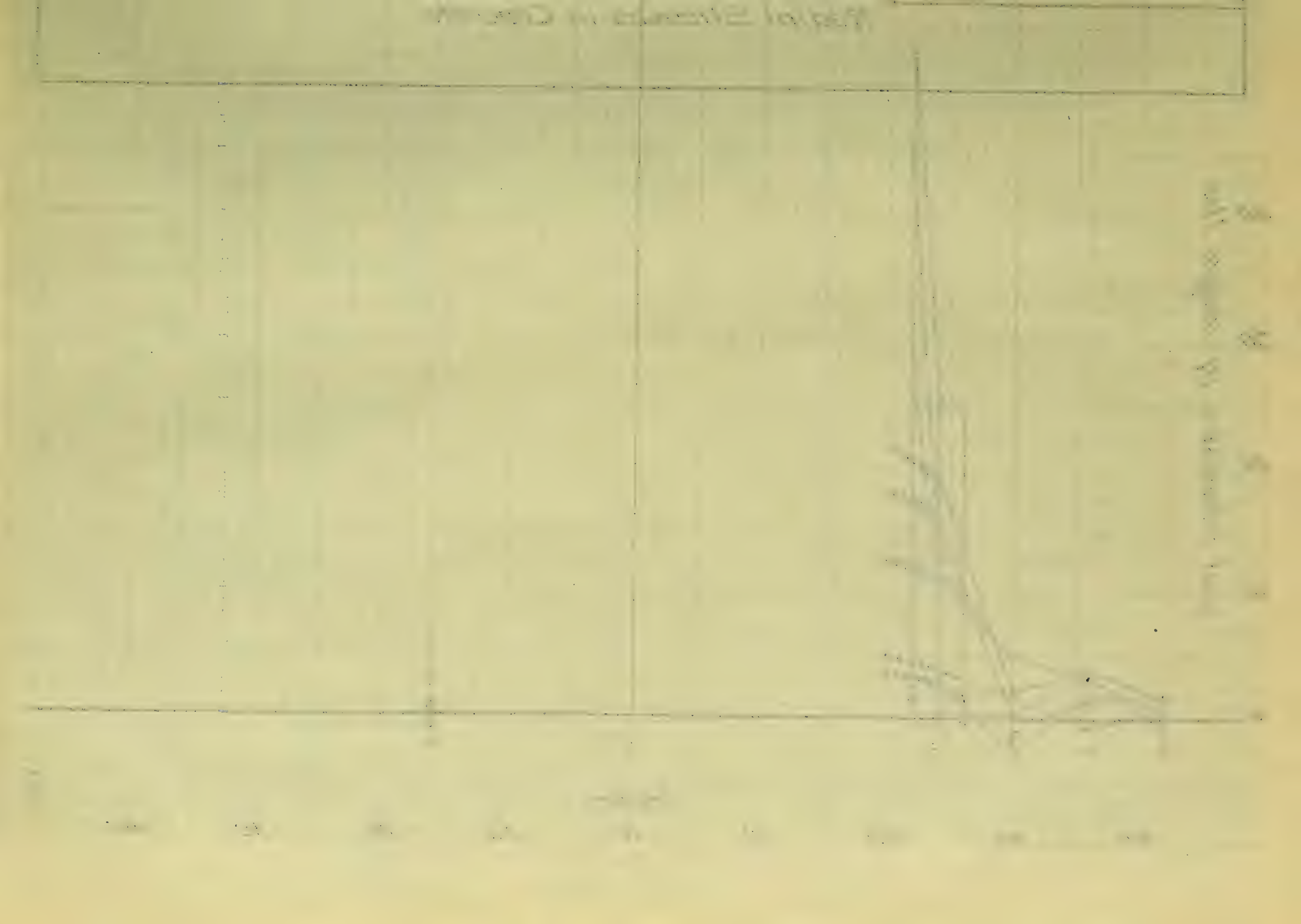


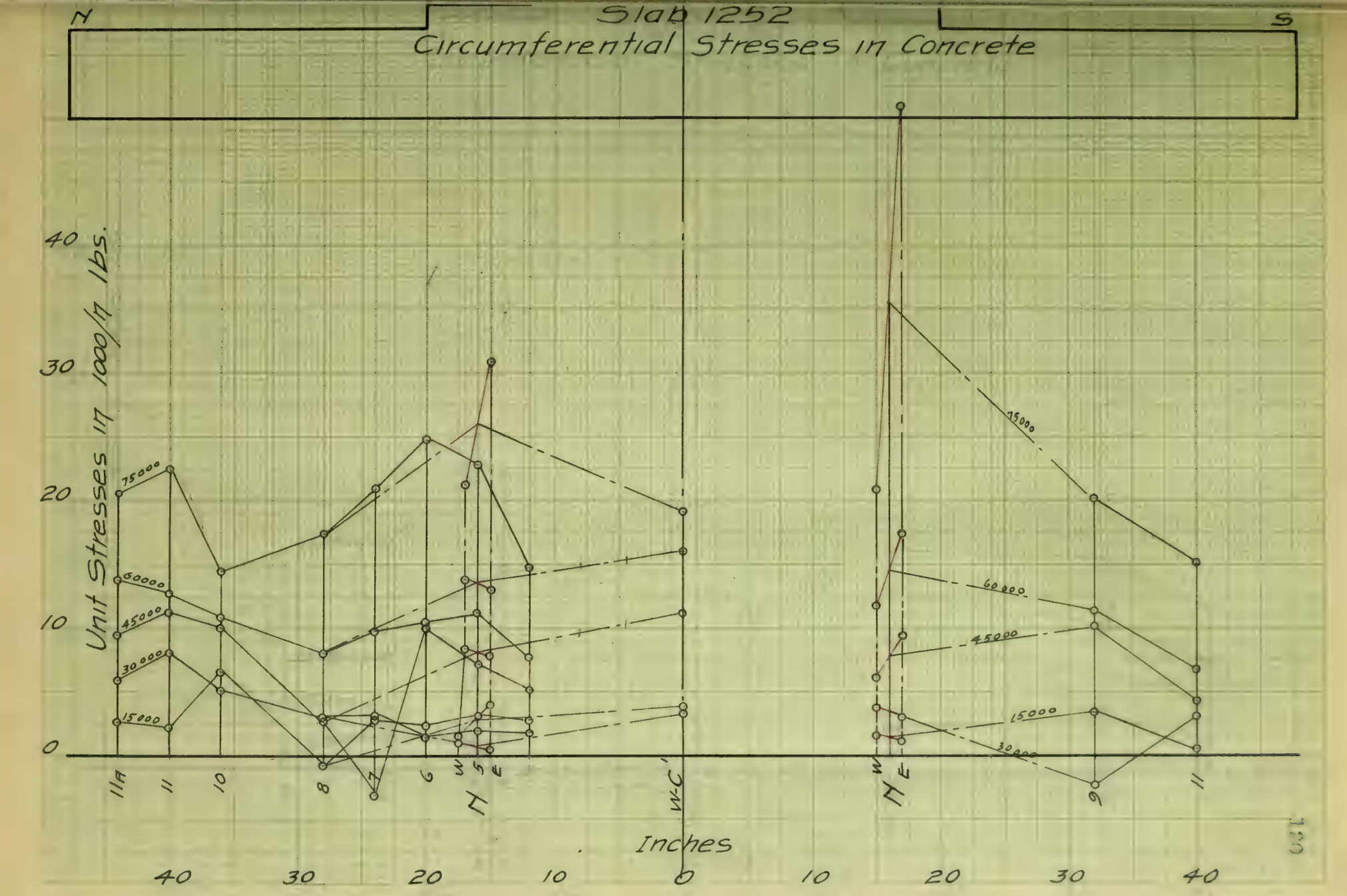

Slab 1252
Circumferential Stresses in Steel
N
S
75000
60000
45000
30000
15000
40
30
20
10
0
Unit Stress in 1000 lbs.
11
10
9
8
7
6
NW-N
NE-H
5
4
3
2
N-D
1
S-D
W
E
7
9
11
Inches
40
30
20
10
0
10
20
30
40

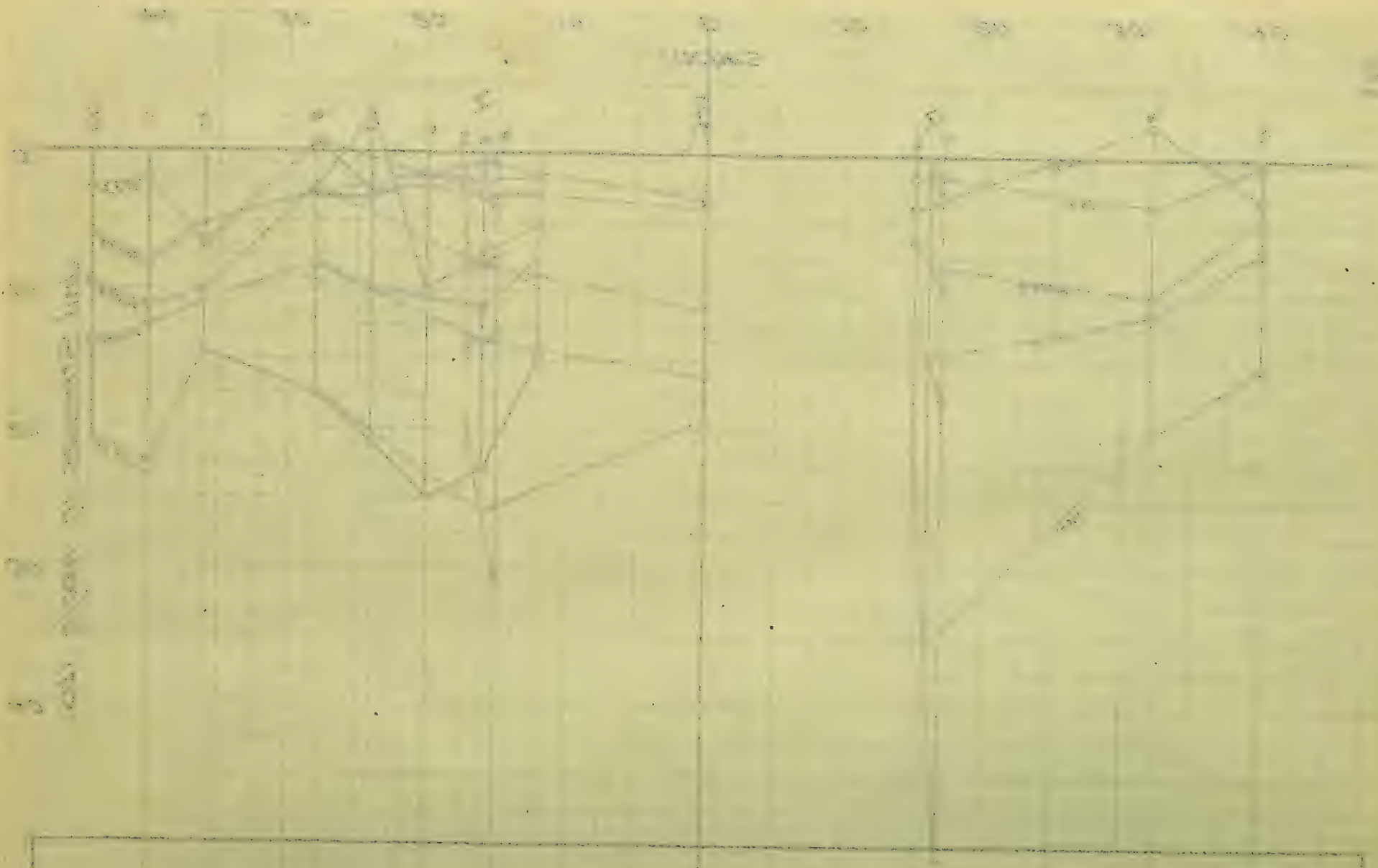


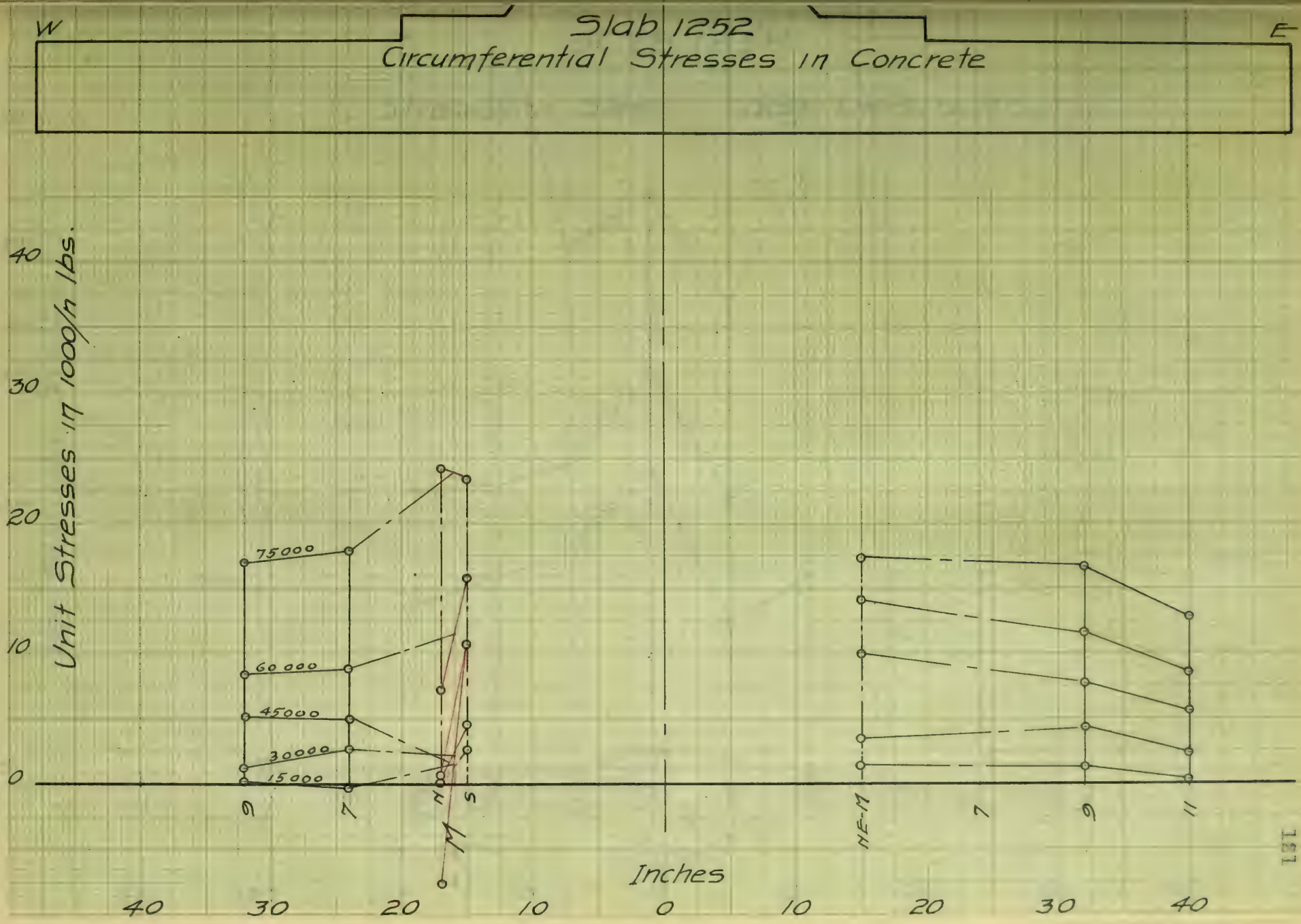

N
Slab 1252
Radial Stresses in Concrete
S
Unit Stresses in 1000/n lbs.
40
30
20
10
0
E
D
C-3
C-2
C
C'
2
3
Inches
40
30
20
10
0
10
20
30
40
118


W
Slab 1252
Radial Stresses in Concrete
E
Unit Stresses in 1000's lbs.
40
30
20
10
0
60000
75000
45000
15000
30000
F
E
D
C'2
1
C
Inches
40
30
20
10
0
10
20
30
40
119



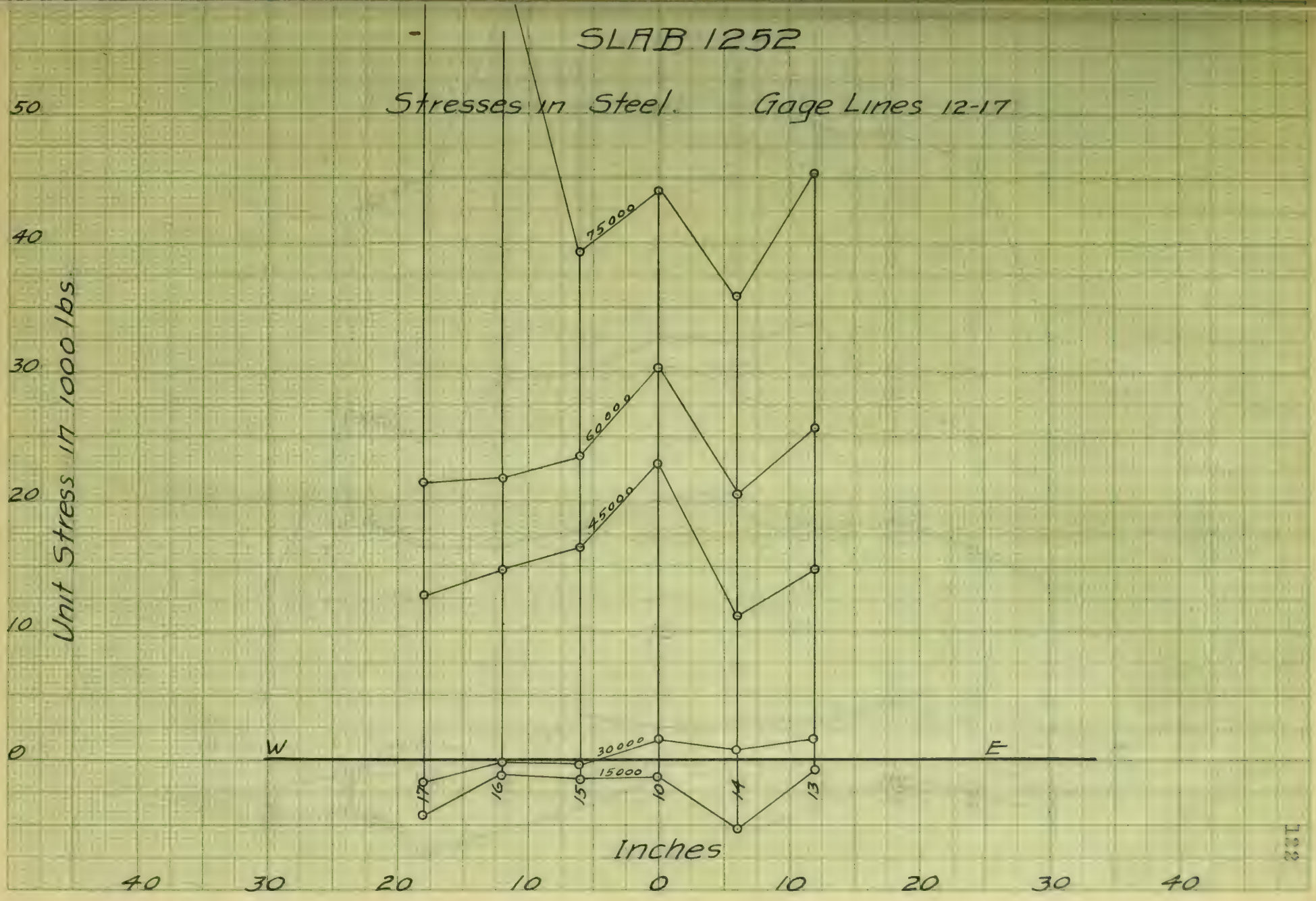

N
Slab 1252
Circumferential Stresses in Concrete
S
Unit Stresses in 1000/# lbs.
40
30
20
10
0
75000
60000
45000
30000
15000
45000
60000
45000
15000
30000
11A
11
10
8
7
6
W
5
E
N
W-C
W
N
E
9
11
Inches
40
30
20
10
0
10
20
30
40

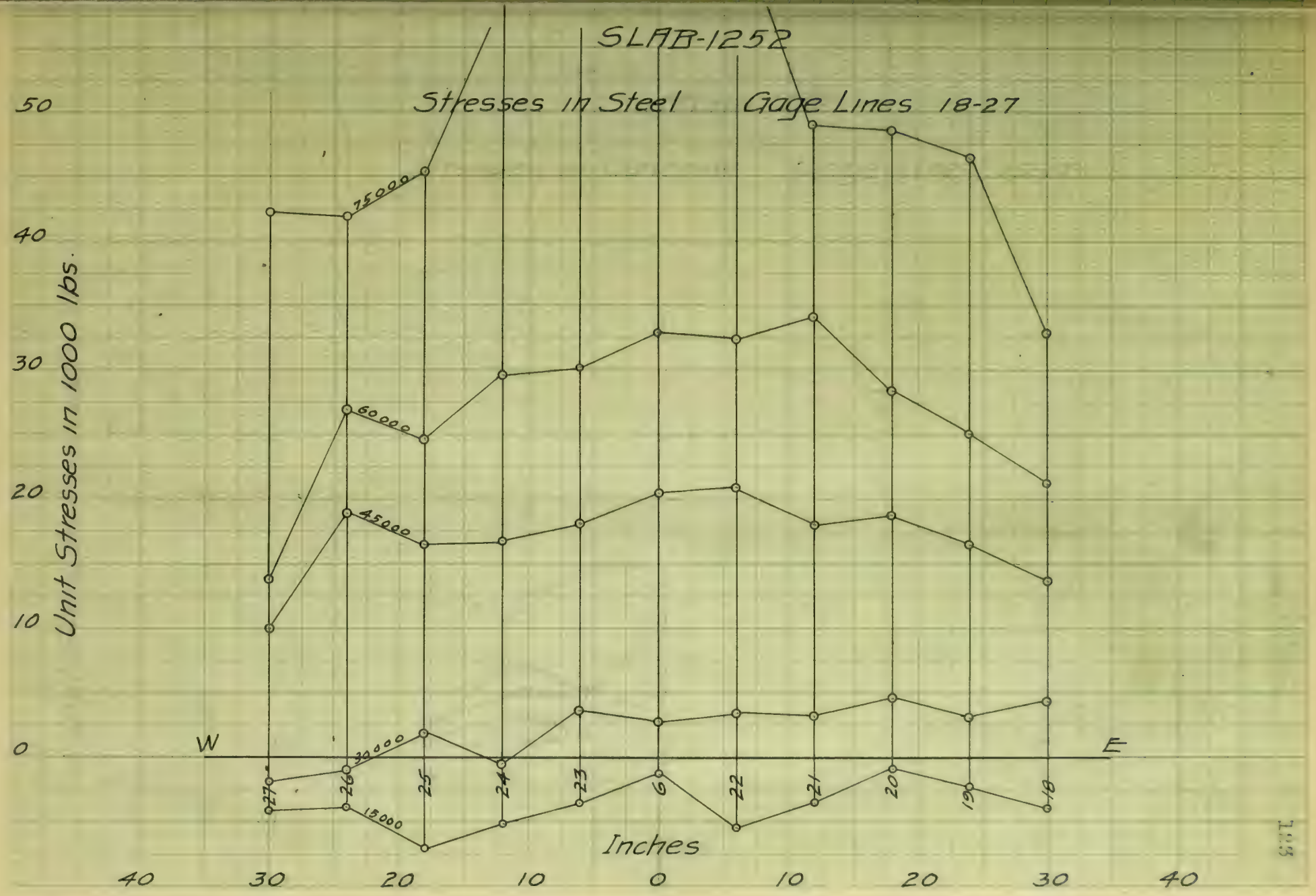



W
E
Slab 1252
Circumferential Stresses in Concrete
Unit Stresses in 1000's lbs.
40
30
20
10
0
75000
60000
45000
30000
15000
9
7
N
S
M
NE-M
7
9
11
Inches
40
30
20
10
0
10
20
30
40
131

SLAB 1252

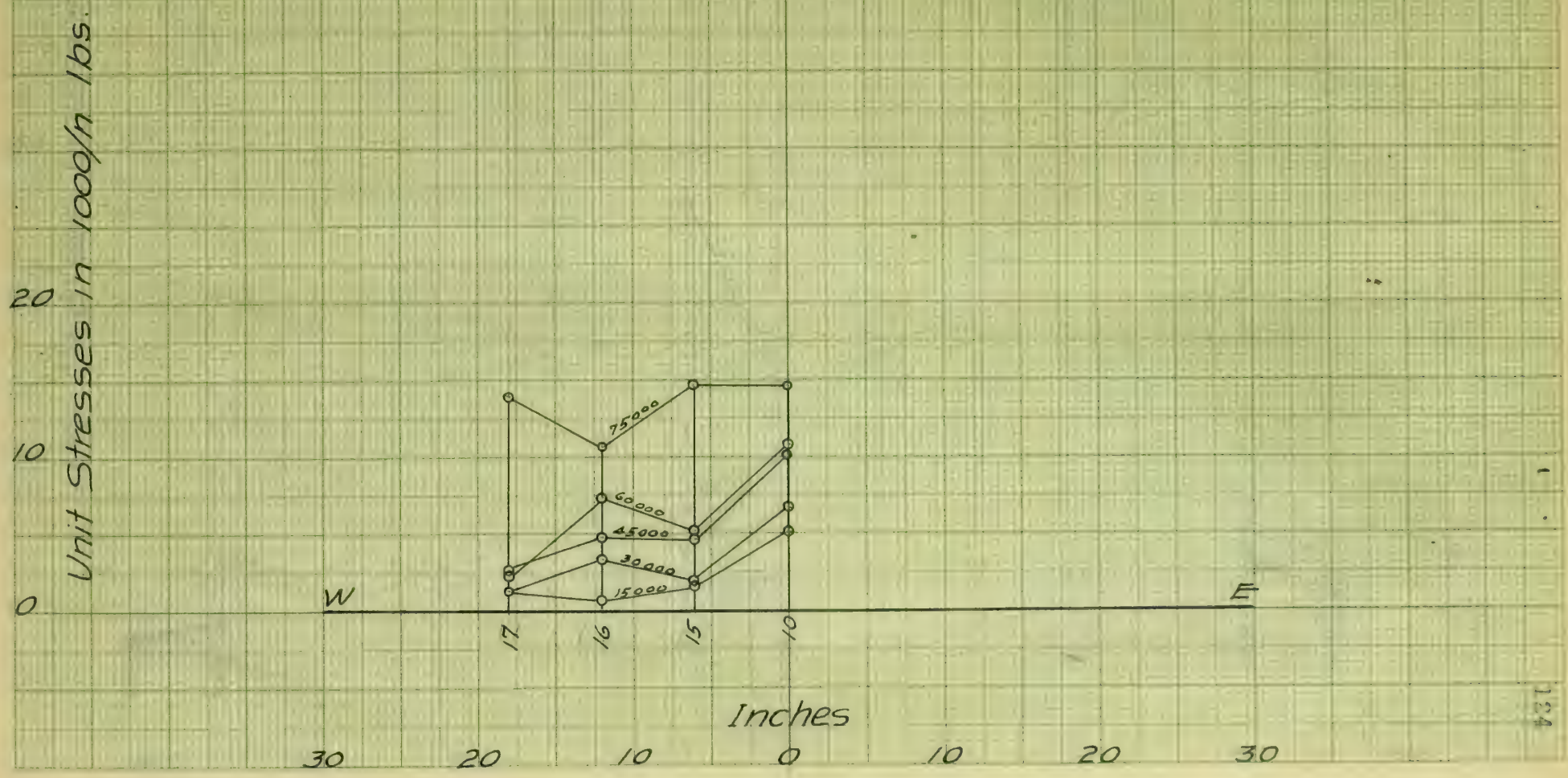
Stresses in Steel. Gage Lines 12-17




SLAB-1252
Stresses in Steel Gage Lines 18-27
Unit Stresses in 1000 lbs.
50
40
30
20
10
0
75000
60000
45000
30000
15000
W
E
27
26
25
24
23
6
22
21
20
19
18
Inches
40
30
20
10
0
10
20
30
40

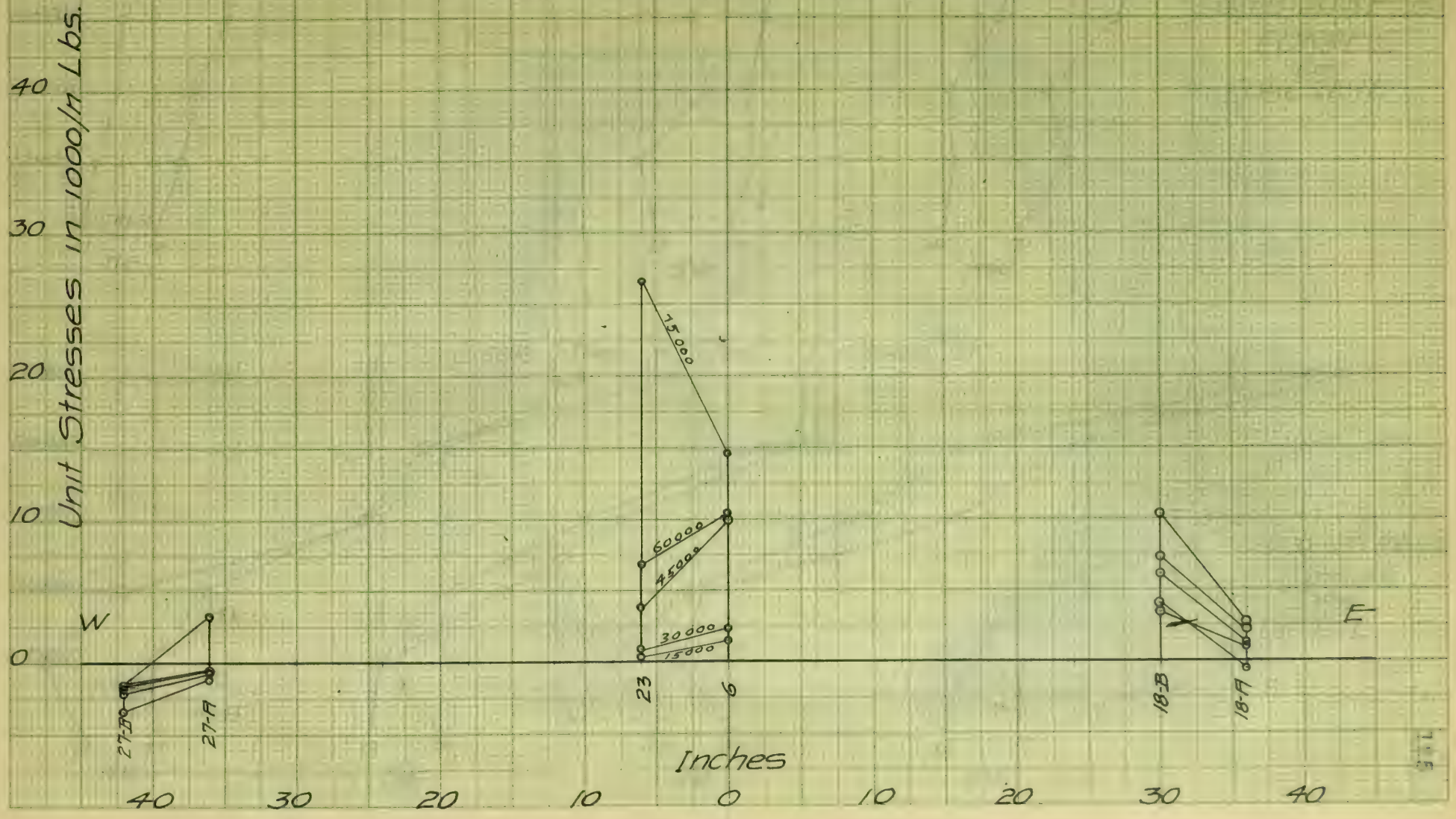
SLAB 1252

Stresses in Concrete Gage Lines 15-17

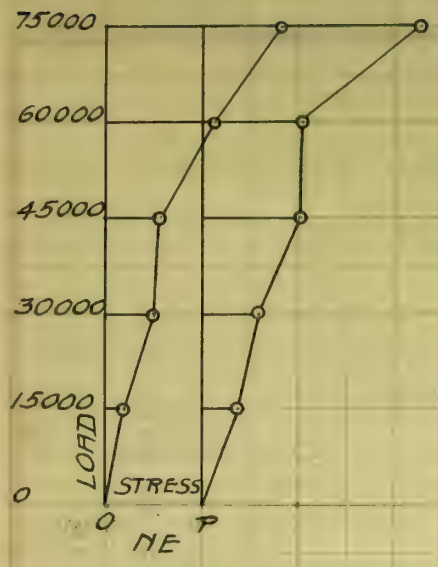


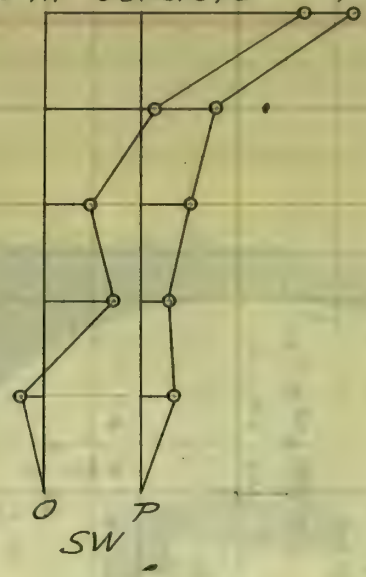
SLAB 1252

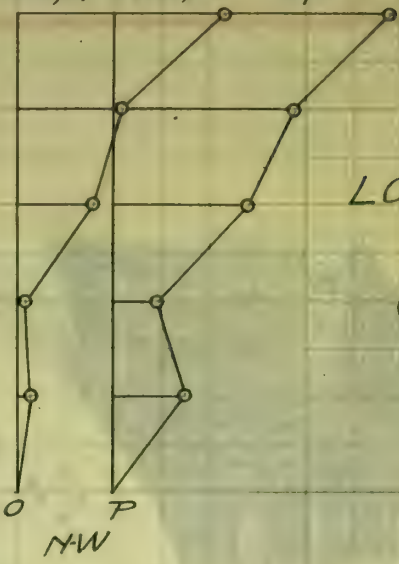
Concrete Stresses Gage Lines 18-27



Scale - Stress in Concrete 1" = 1000/n lbs. per Sq. In.

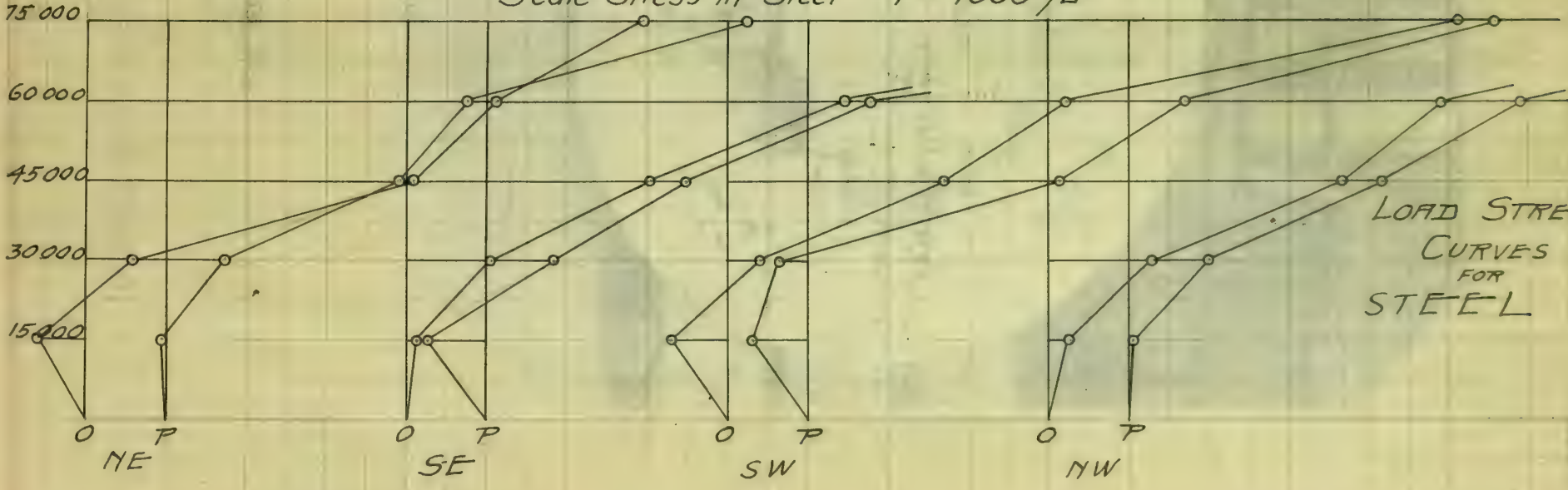






LOAD STRESS CURVES FOR CONCRETE

Scale Stress in Steel 1" = 1000#/□"



LOAD STRESS CURVES FOR STEEL

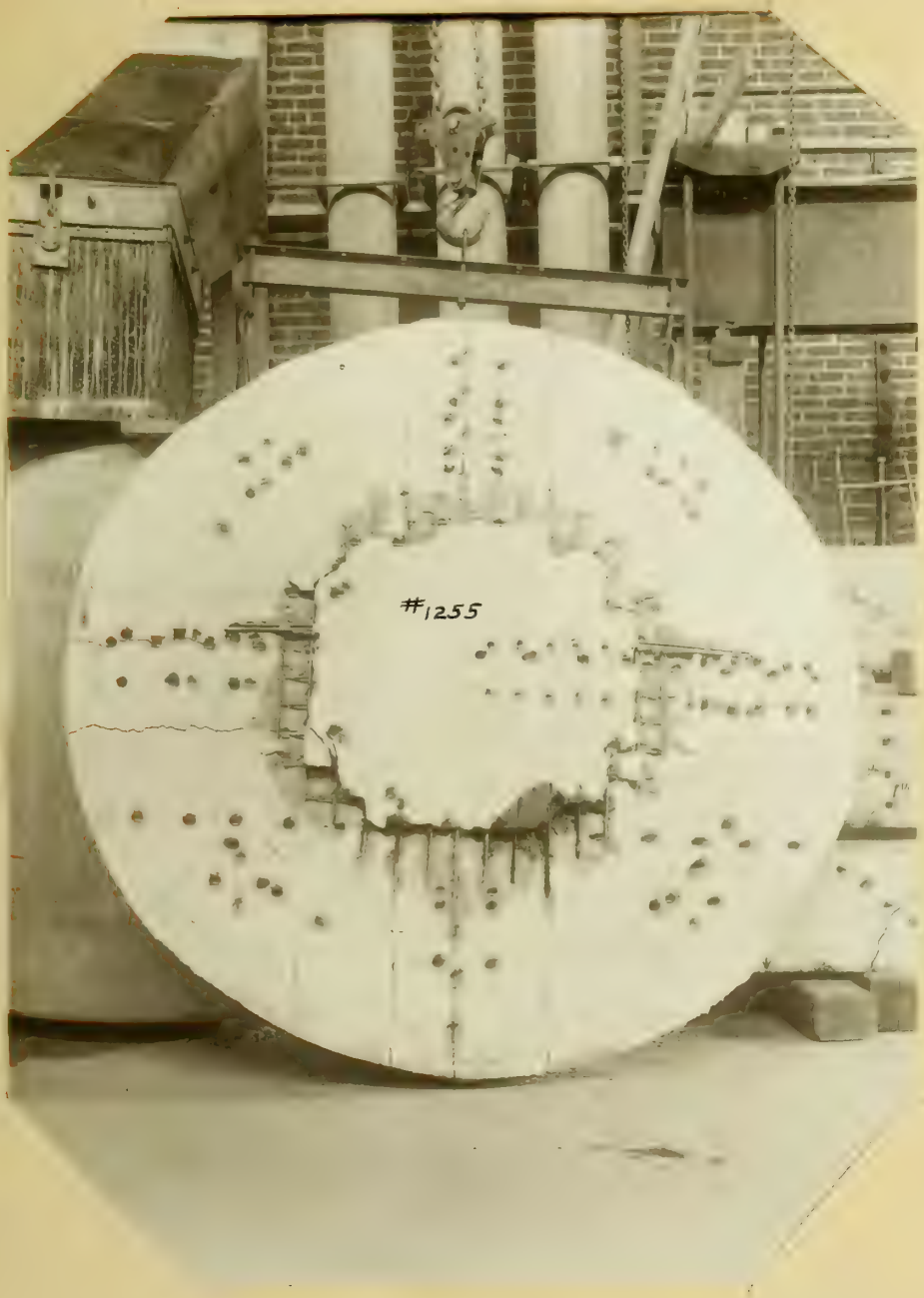


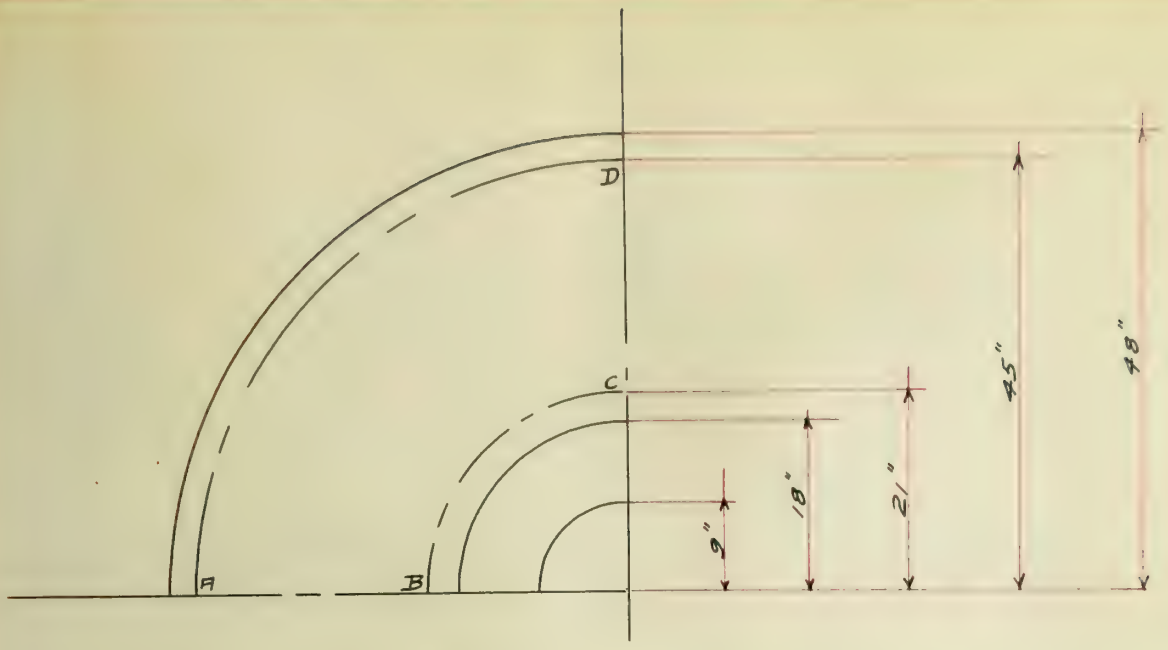
Figure 25.

VIEW OF BLADE # 1255 AFTER TESTING.

B. Slab with both Rectangular and Circumferential Reinforcement and a 36 inch cap.

22. Phenomena of Tests. Slabs 1255 and 1256 come under the above heading and the action of the two were similar except in one respect. In slab 1256 the rods over the cap failed in bond and in 1255 this did not occur. This was probably due to the the difference in the bond resistances of the two concretes due to some factors which are not very evident from the load-deformation curves of the cylinders or cubes. The occurrence of cracks in these two specimens was practically the same as in slab 1253 which had the same sized cap but rectangular reinforcement only. Both of these slabs failed primarily by tension in the steel and ultimately by punching through the cap. When these slabs were broken up after finishing the test, it was noticed that almost of the hoops were broken at the weld.

23. Load Deformation Relations. The only varied difference in any of the deformations occurring in these two slabs at the same loads was that the circumferential concrete stresses were much higher in slab 1256. This is probably due only to the fact that in slab 1256 the stress in the rods passing over the cap remained almost a maximum to the center instead of reducing to almost zero at the center as was the case with slab 1255. This acts to produce a much larger integral of total radial stresses from the center up to any point, which causes a greater value of the circumferential deformations.



Slab 1255.

Equilibrium Calculations.

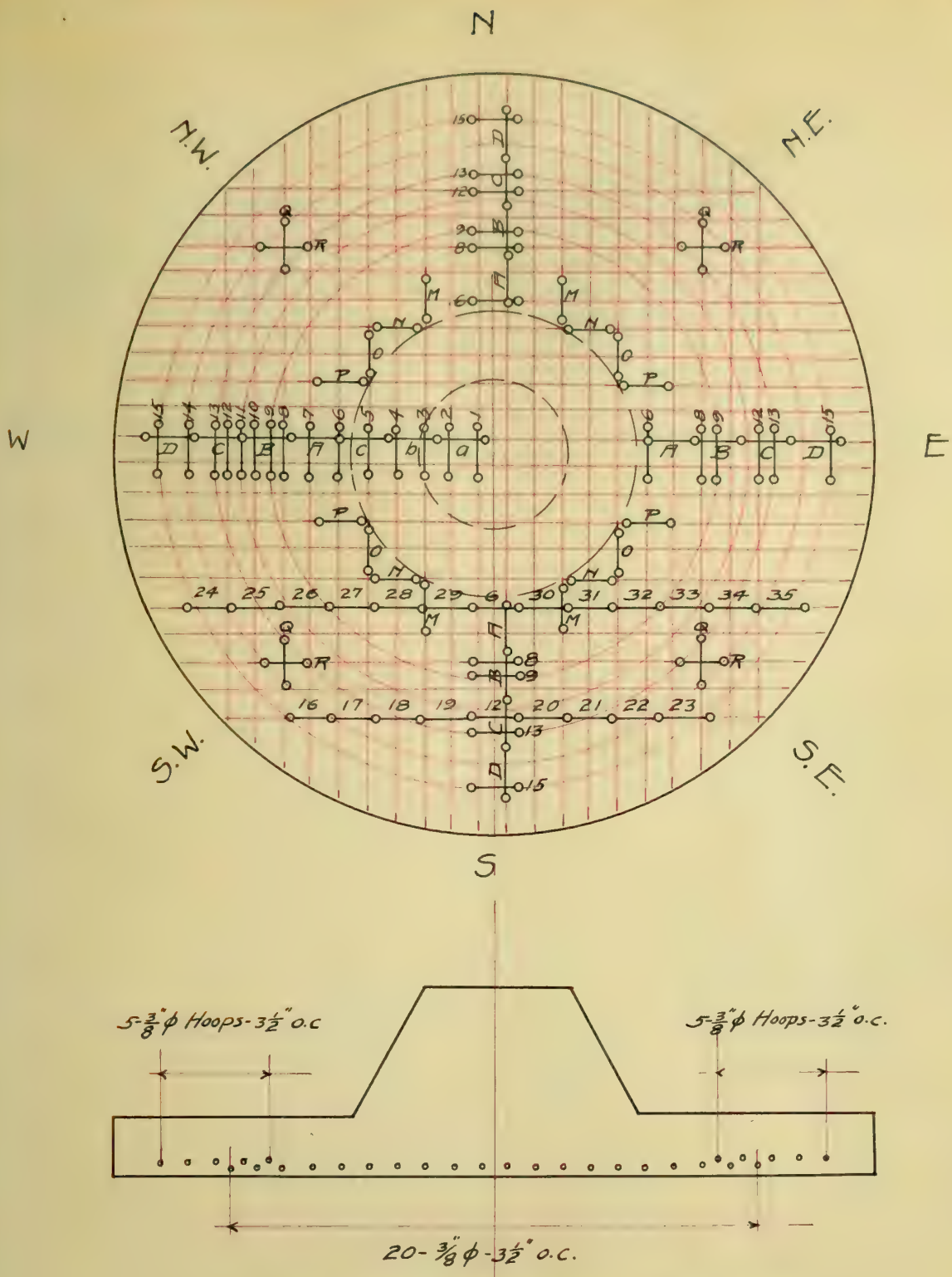
The bending moment equals $.707\frac{(45-21)60000}{4}$ or 255000 inch pounds, in the direction CD on the section ABC. ($M=60000^{\#}$)

14- 3/8 inch diam. rods cut the section.

A_s equals 1.65 sq. inches.

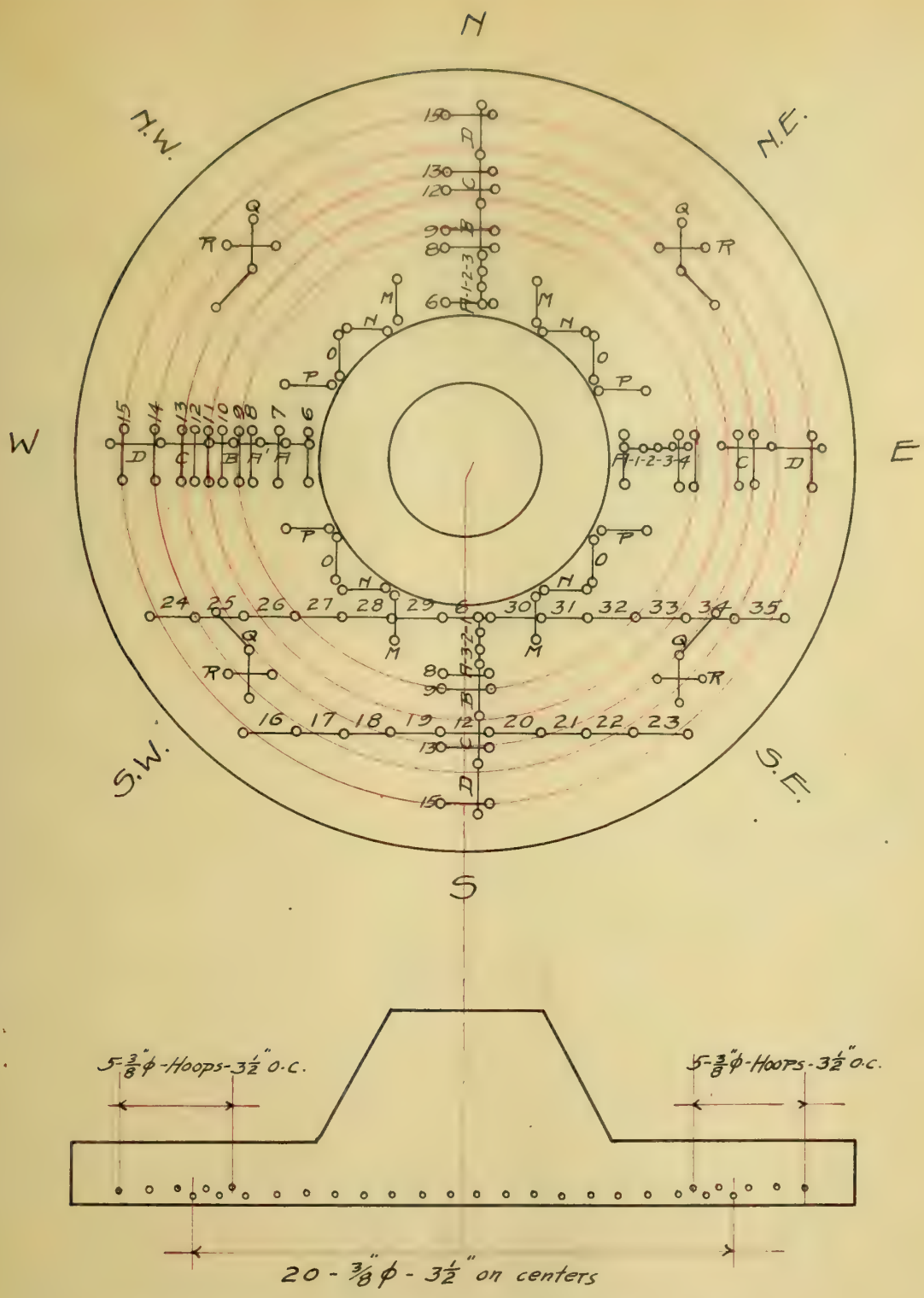
The average steel stress for the load of 60000 pounds equals 27000 pounds per sq. inch, on all the rods cutting the section ABC in the direction CD.

Therefore the effective depth or jD becomes 255000/1.65(27000) or 5.73 inches.



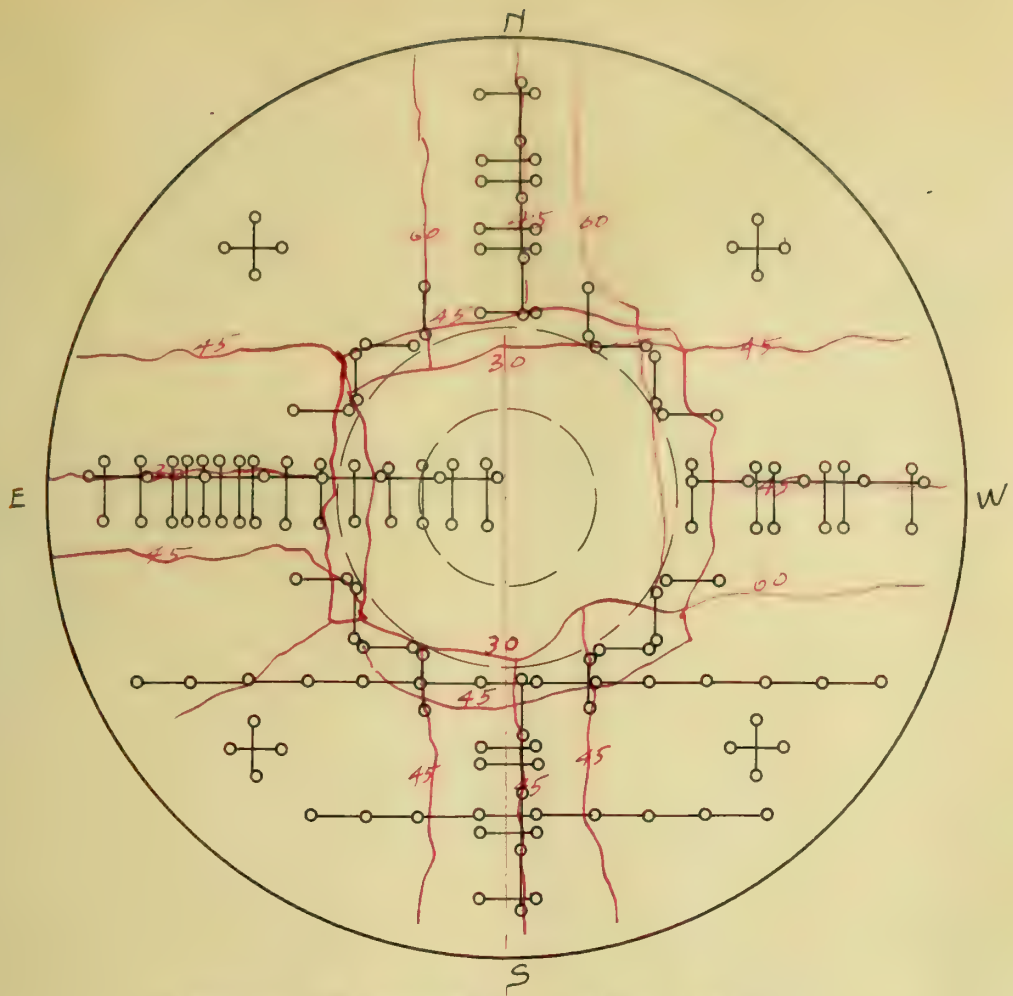
Gage Lines in the Steel. Slab 1255.

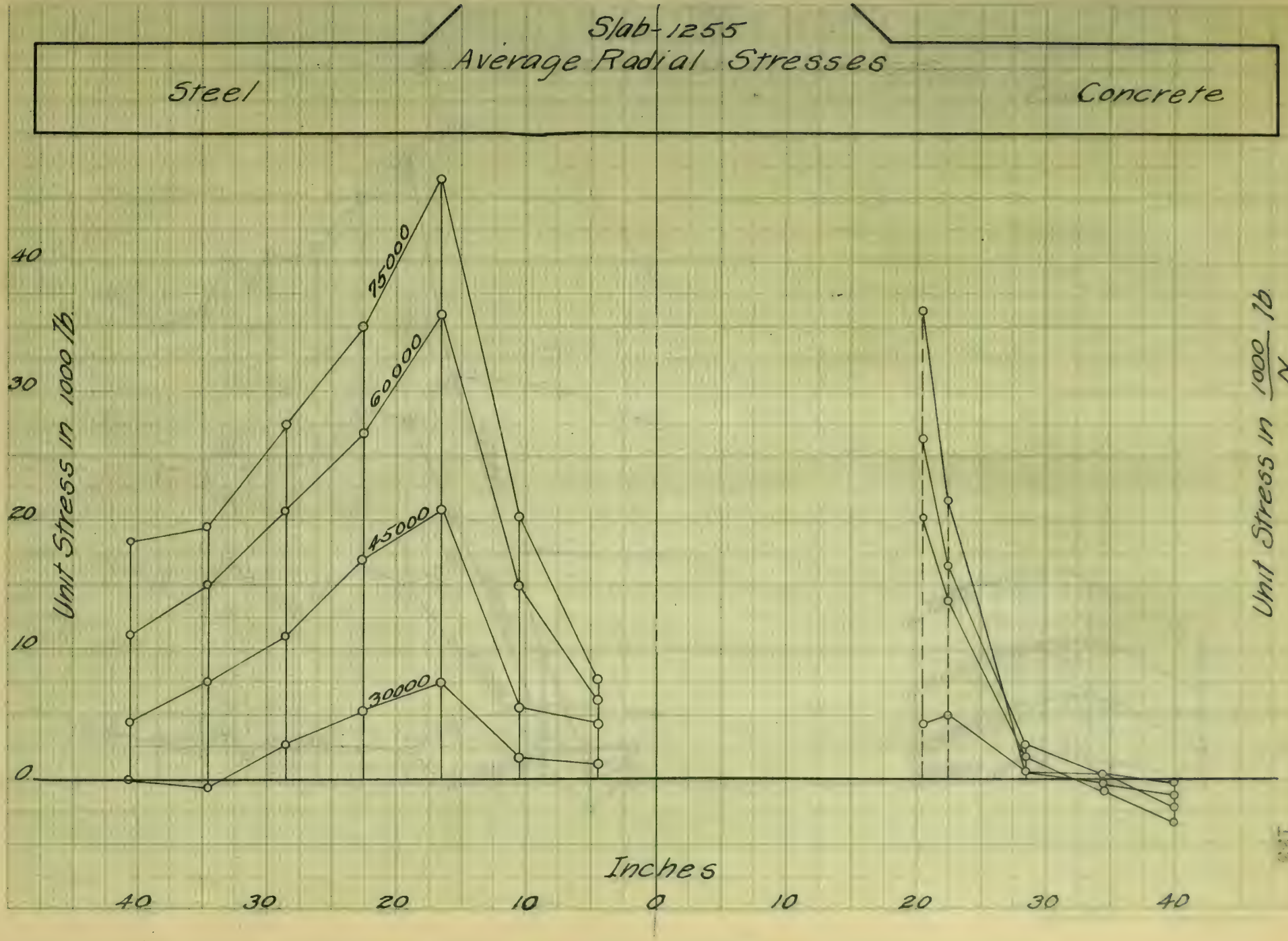
Figure 26.

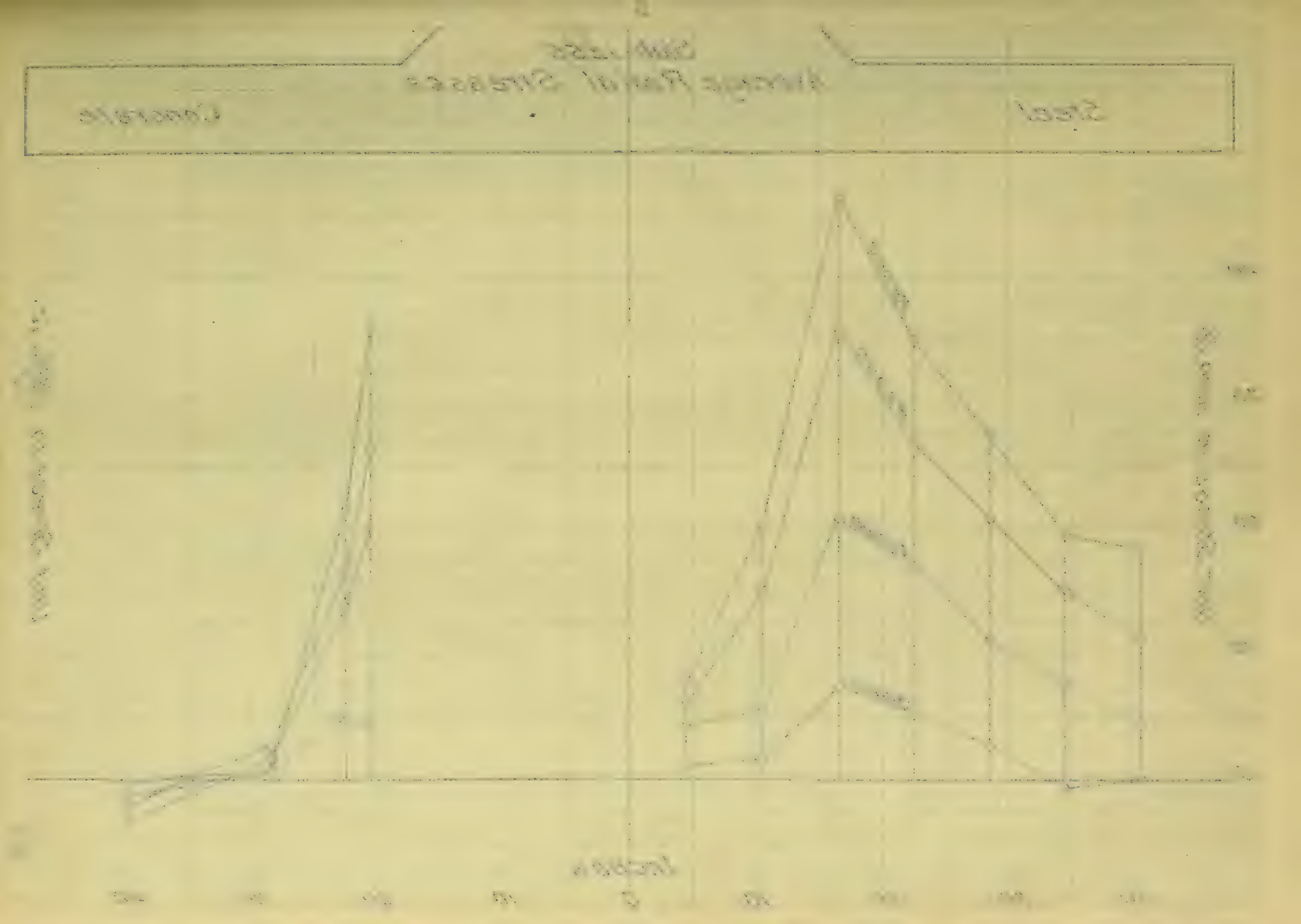


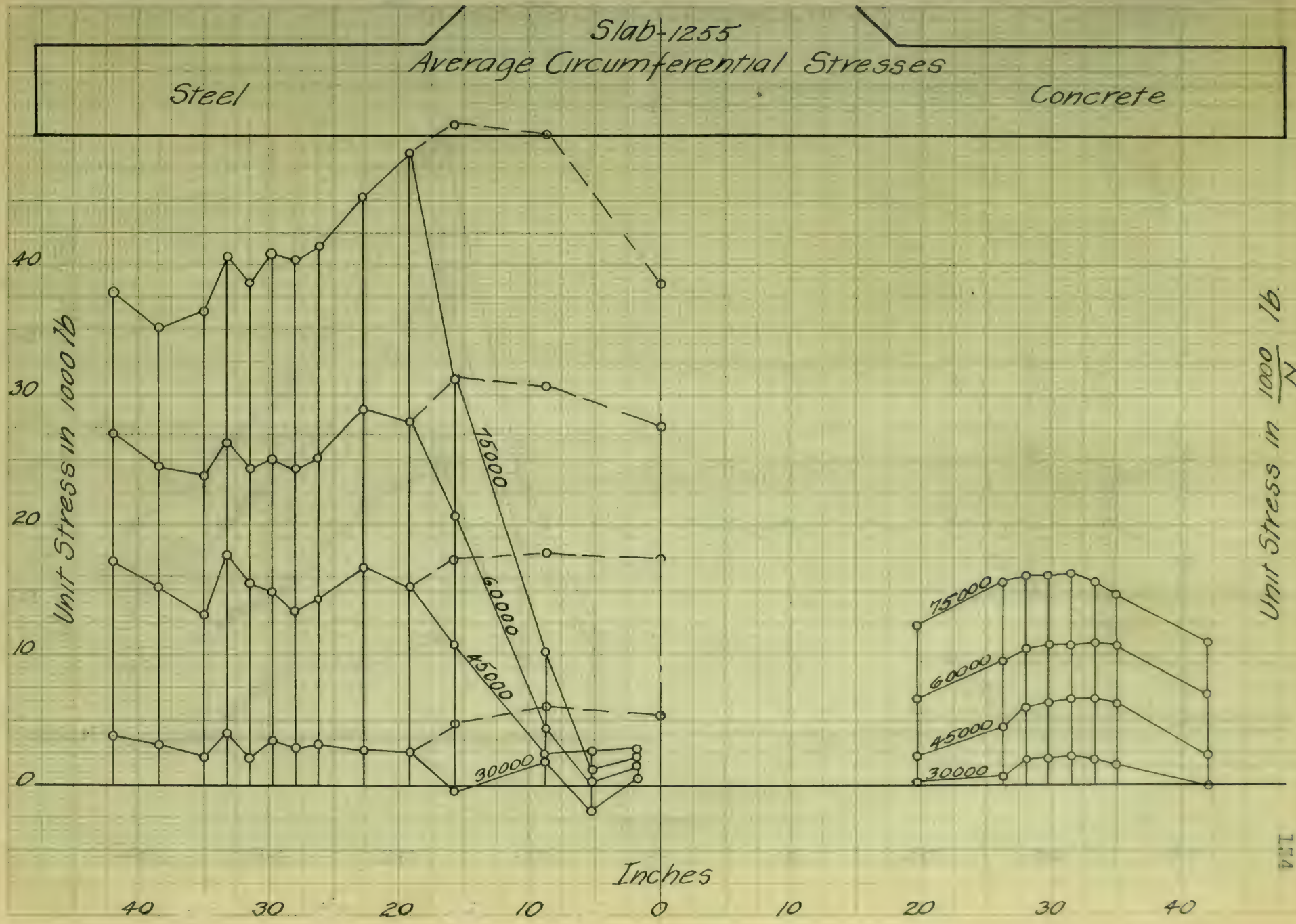
Gage Lines in the Concrete. Slab 1255.

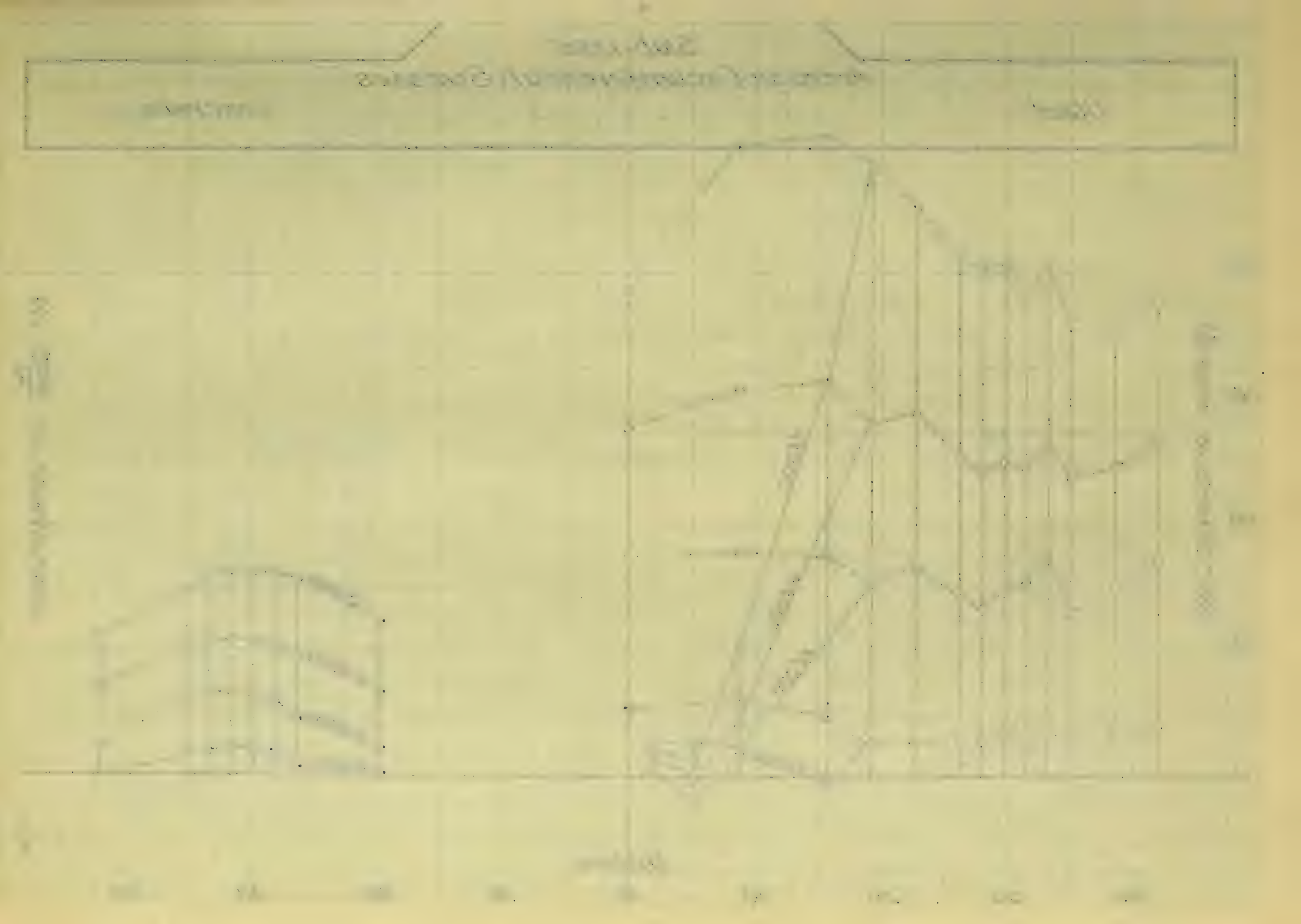
Figure 27.

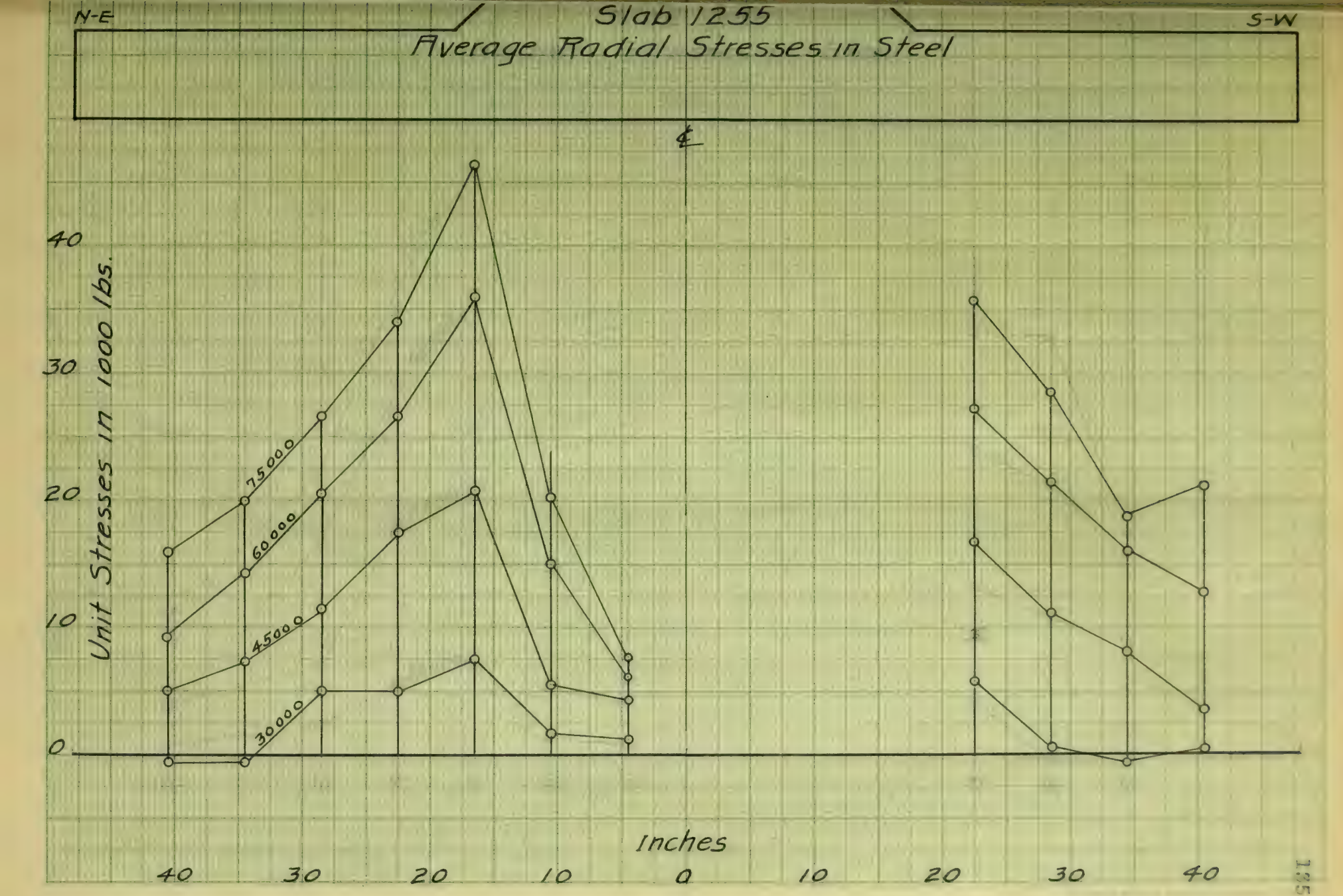

N
E
W
S
60
45
30
45
60
45
45
45
30
45
45
45

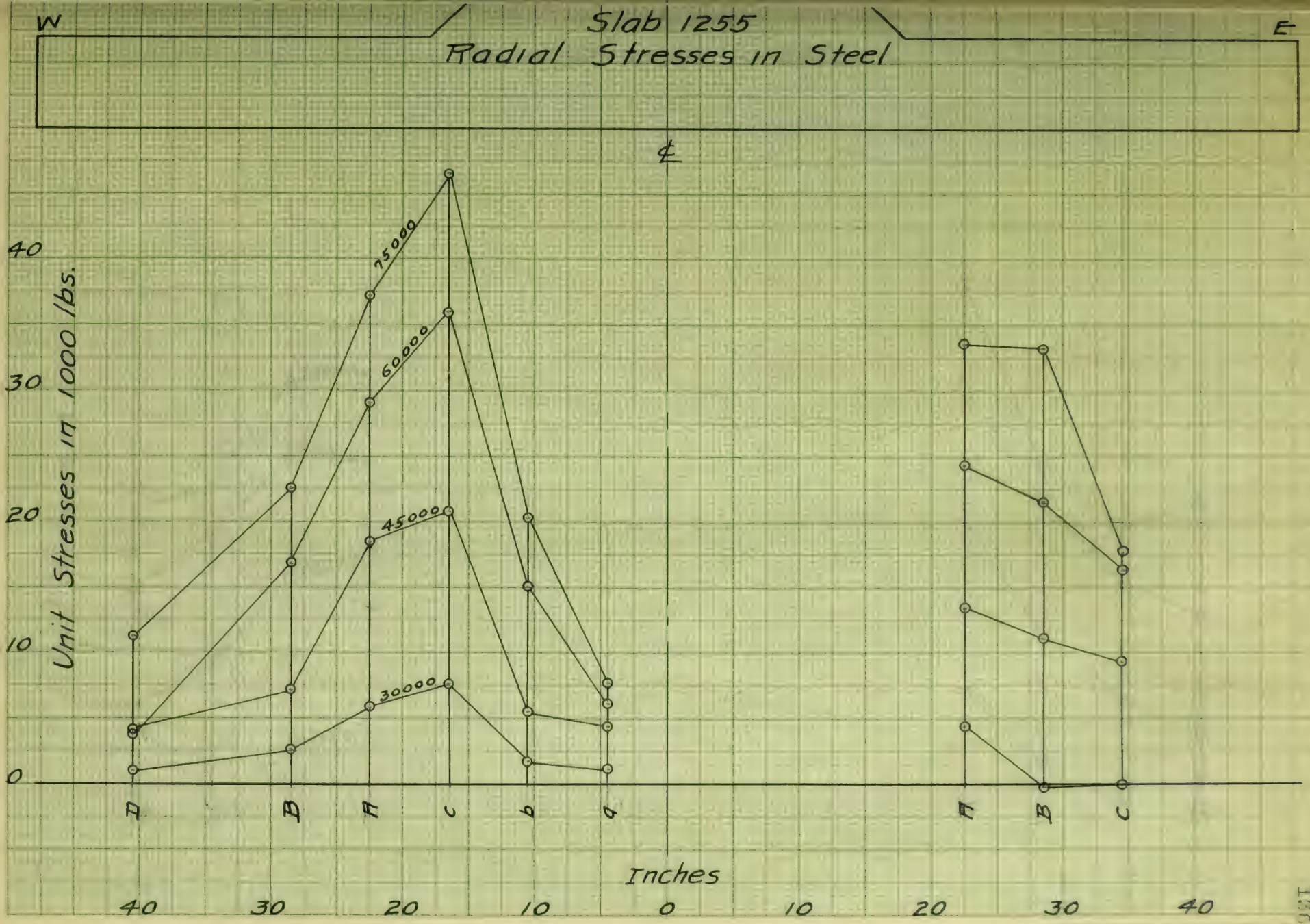

Slab-1255
Average Radial Stresses
Steel
Concrete
75000
60000
45000
30000
40
30
20
10
0
Unit Stress in 1000 lb.
Unit Stress in 1000/N lb.
Inches
40
30
20
10
0
10
20
30
40

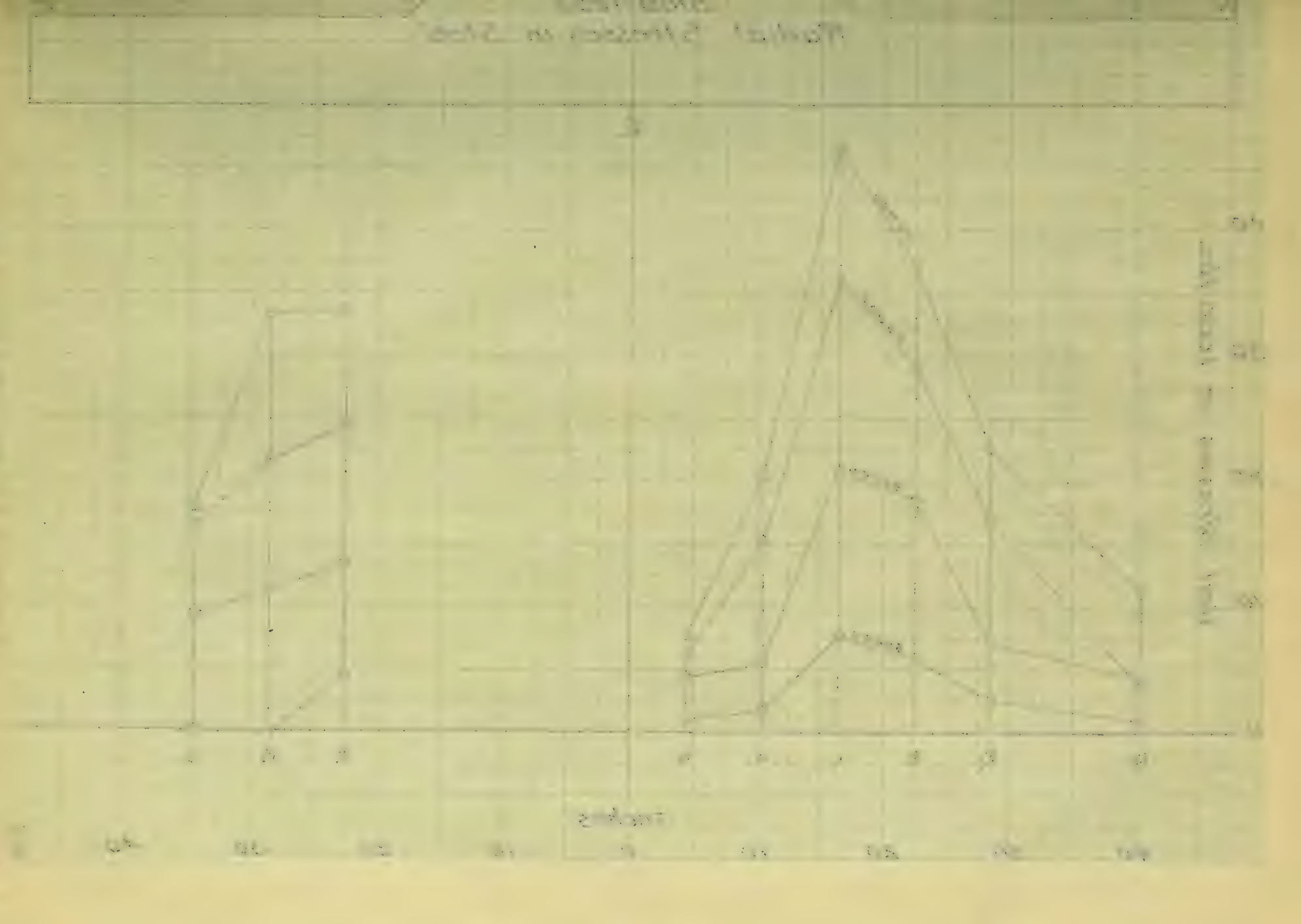


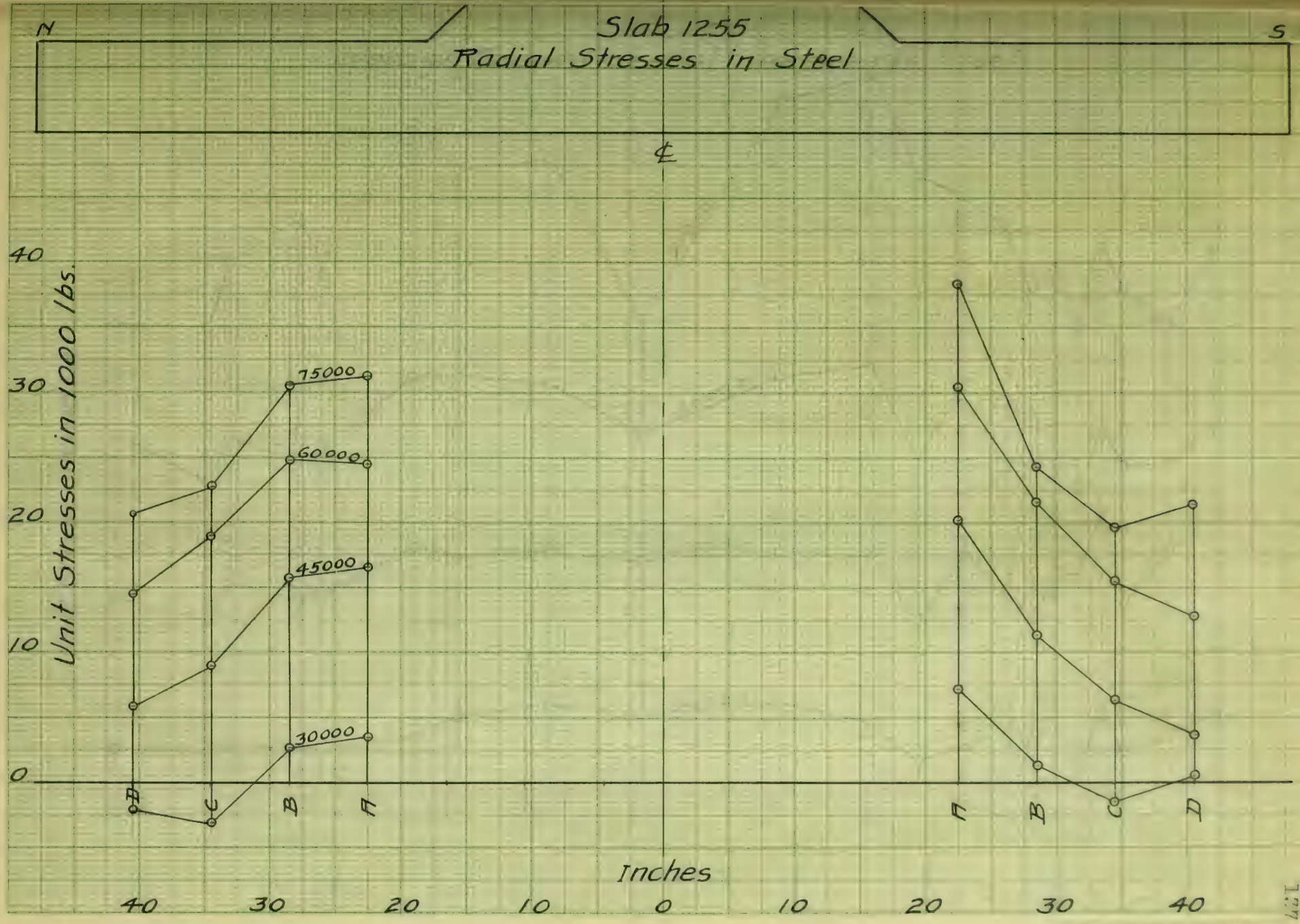

Slab-1255
Average Circumferential Stresses
Steel
Concrete
Unit Stress in 1000 lb.
Unit Stress in 1000/N lb.
40
30
20
10
0
15000
60000
45000
30000
75000
60000
45000
30000
Inches
40
30
20
10
0
10
20
30
40

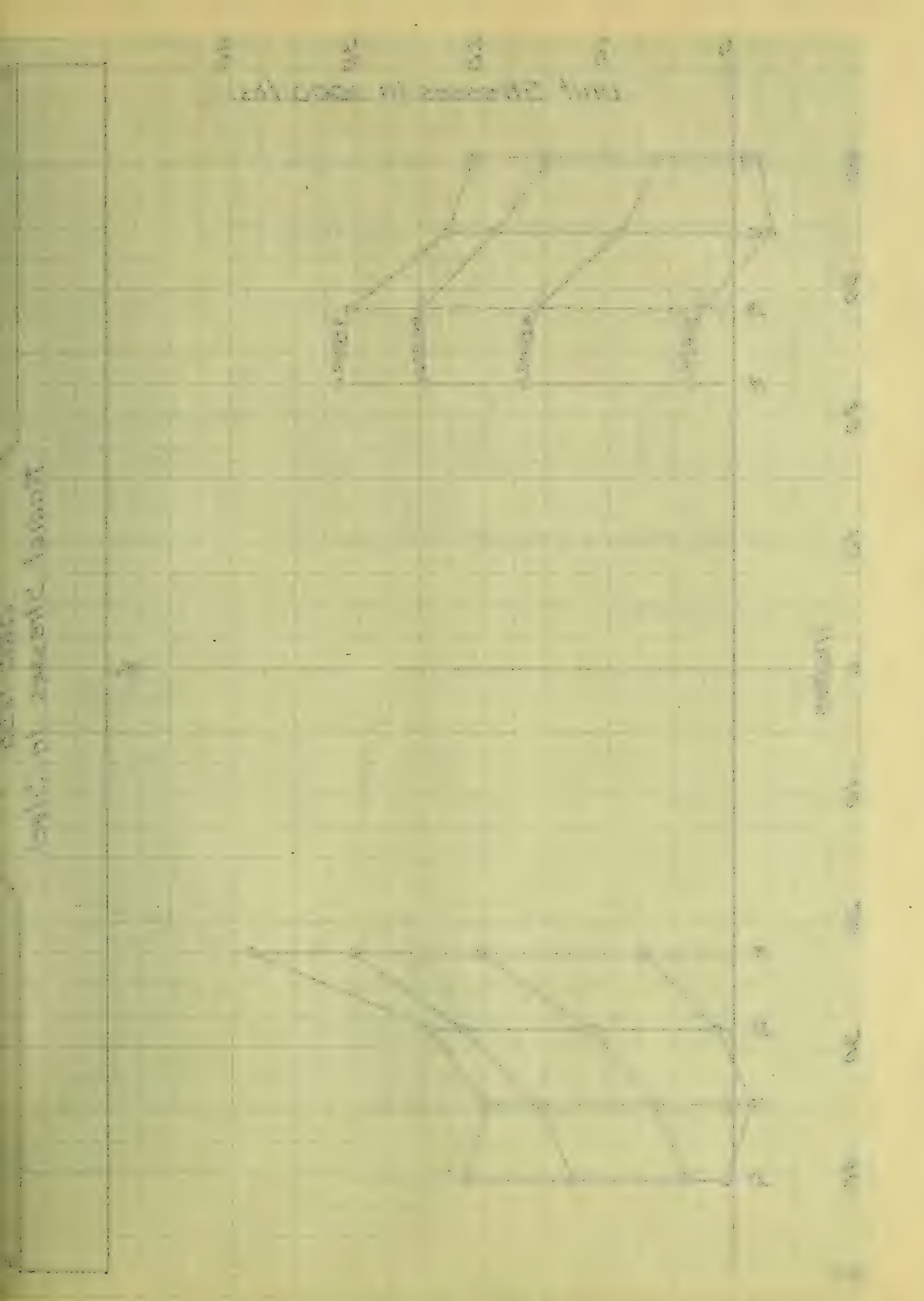


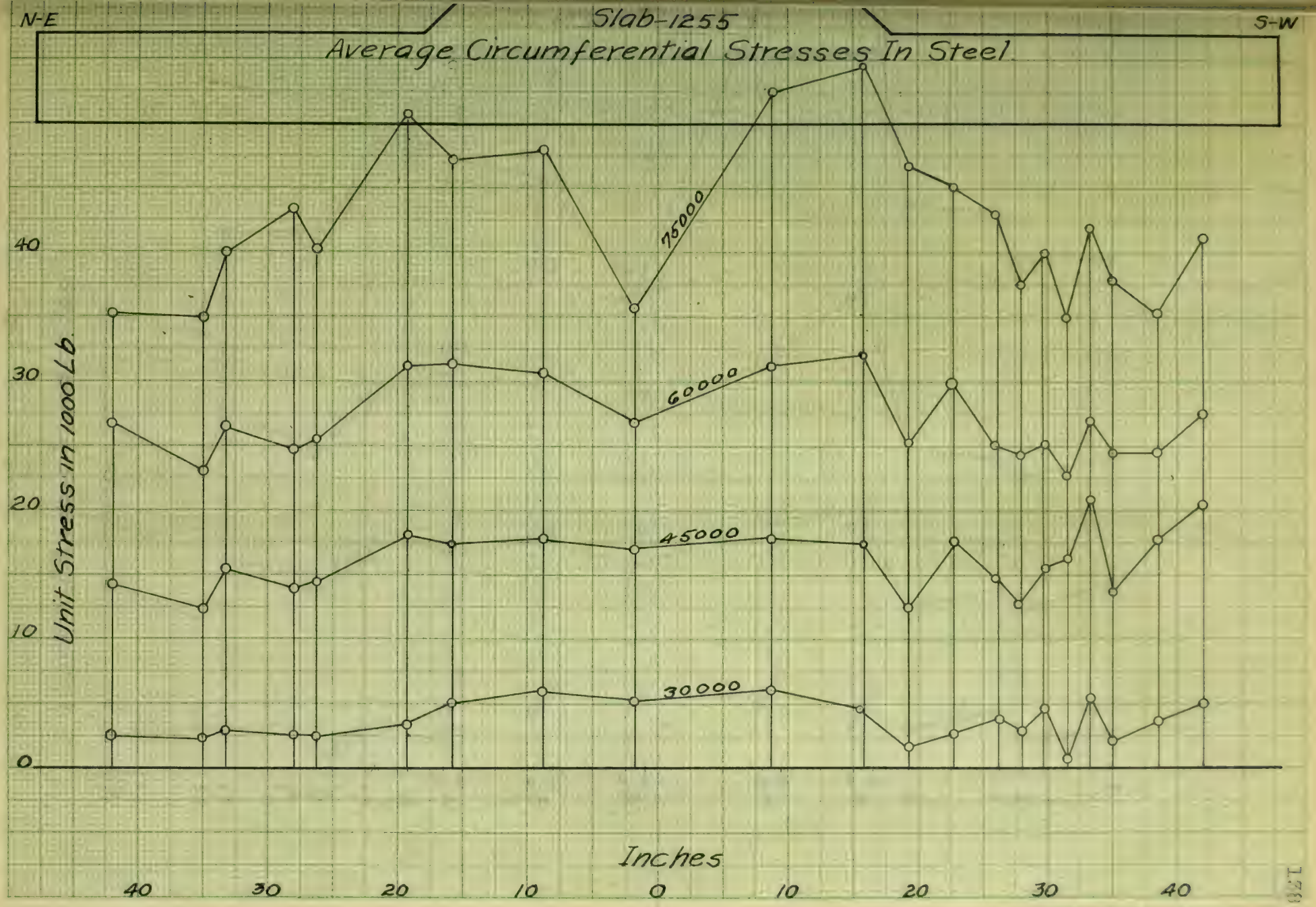

N-E
Slab 1255
S-W
Average Radial Stresses in Steel
℄
40
30
20
10
0
Unit Stresses in 1000 lbs.
75000
60000
45000
30000
Inches
40
30
20
10
0
10
20
30
40
1255

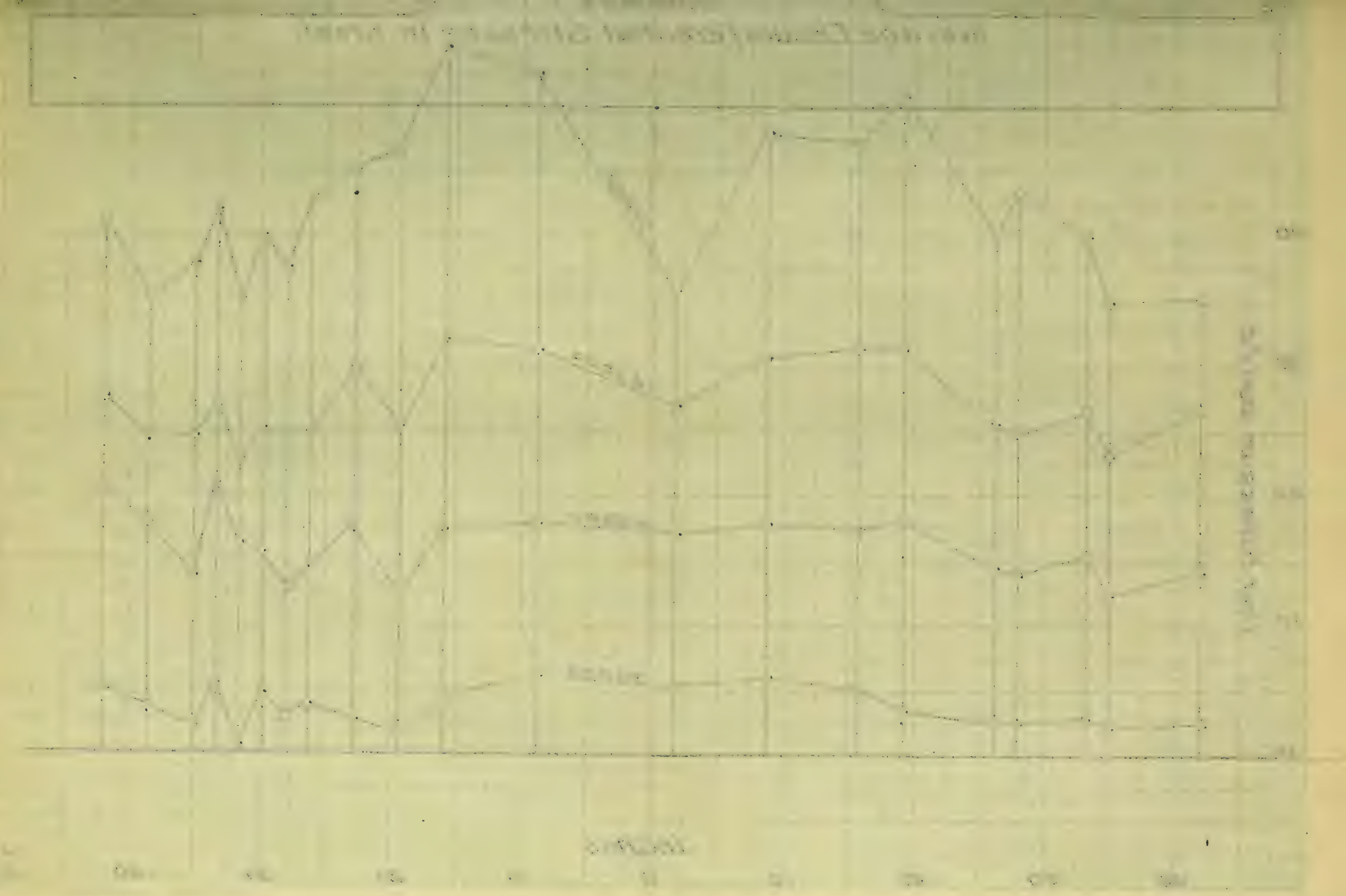

W
Slab 1255
Radial Stresses in Steel
E
℄
40
30
20
10
0
Unit Stresses in 1000 lbs.
75000
60000
45000
30000
D
B
A
C
b
a
A
B
C
Inches
40
30
20
10
0
10
20
30
40

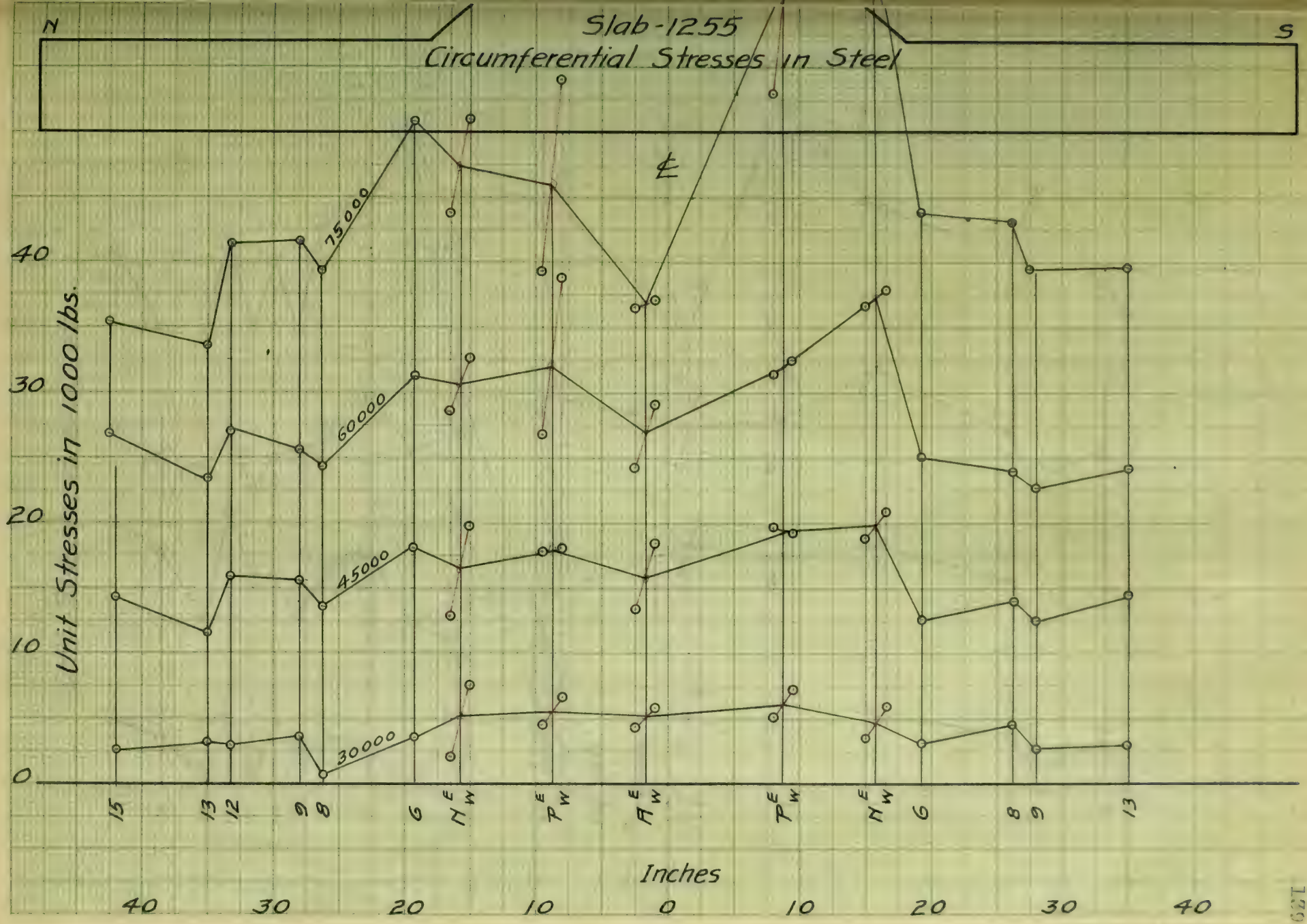


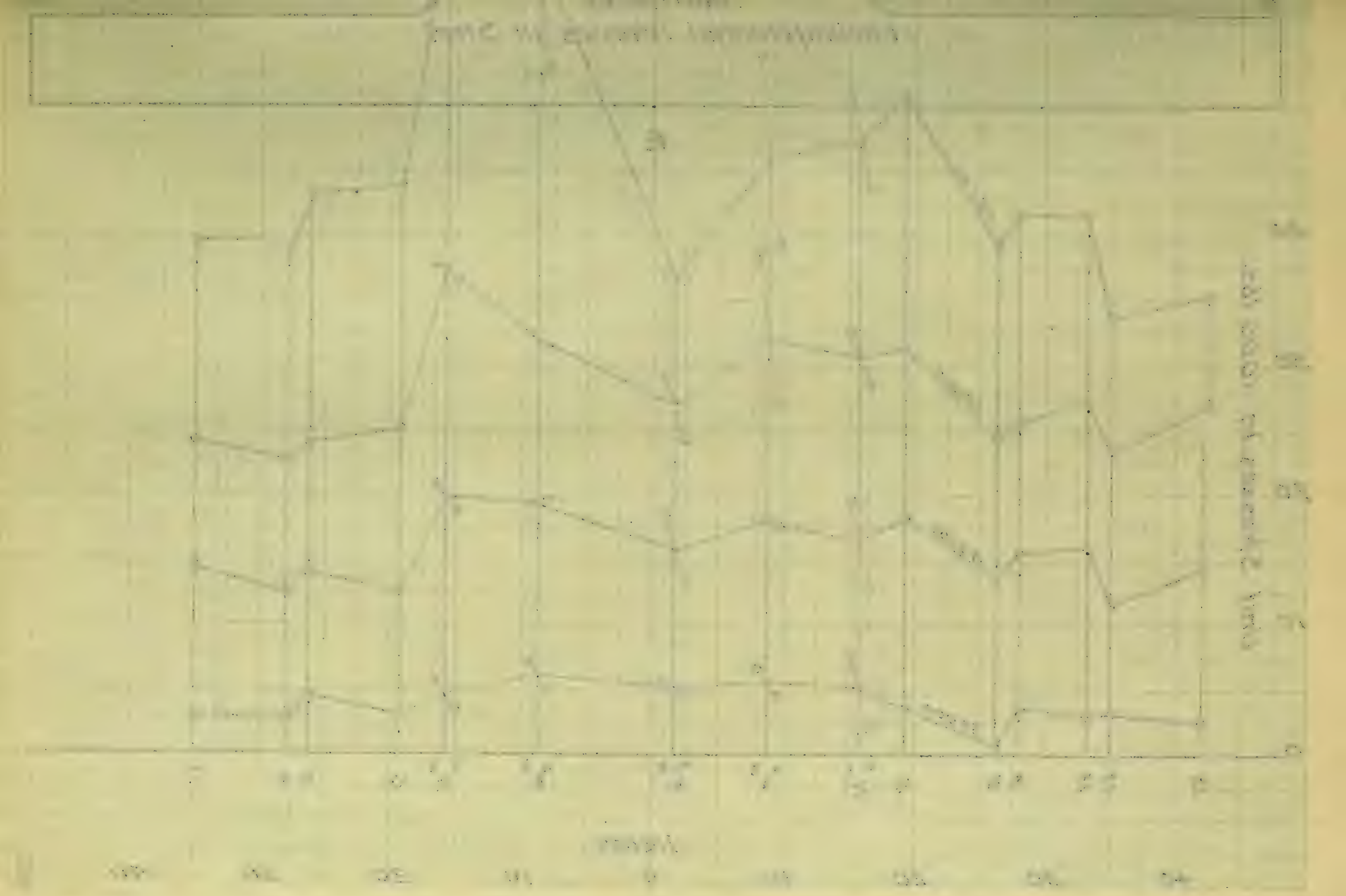

N
S
Slab 1255
Radial Stresses in Steel
℄
40
30
20
10
0
Unit Stresses in 1000 lbs.
75000
60000
45000
30000
D
C
B
A
A
B
C
D
Inches
40
30
20
10
0
10
20
30
40

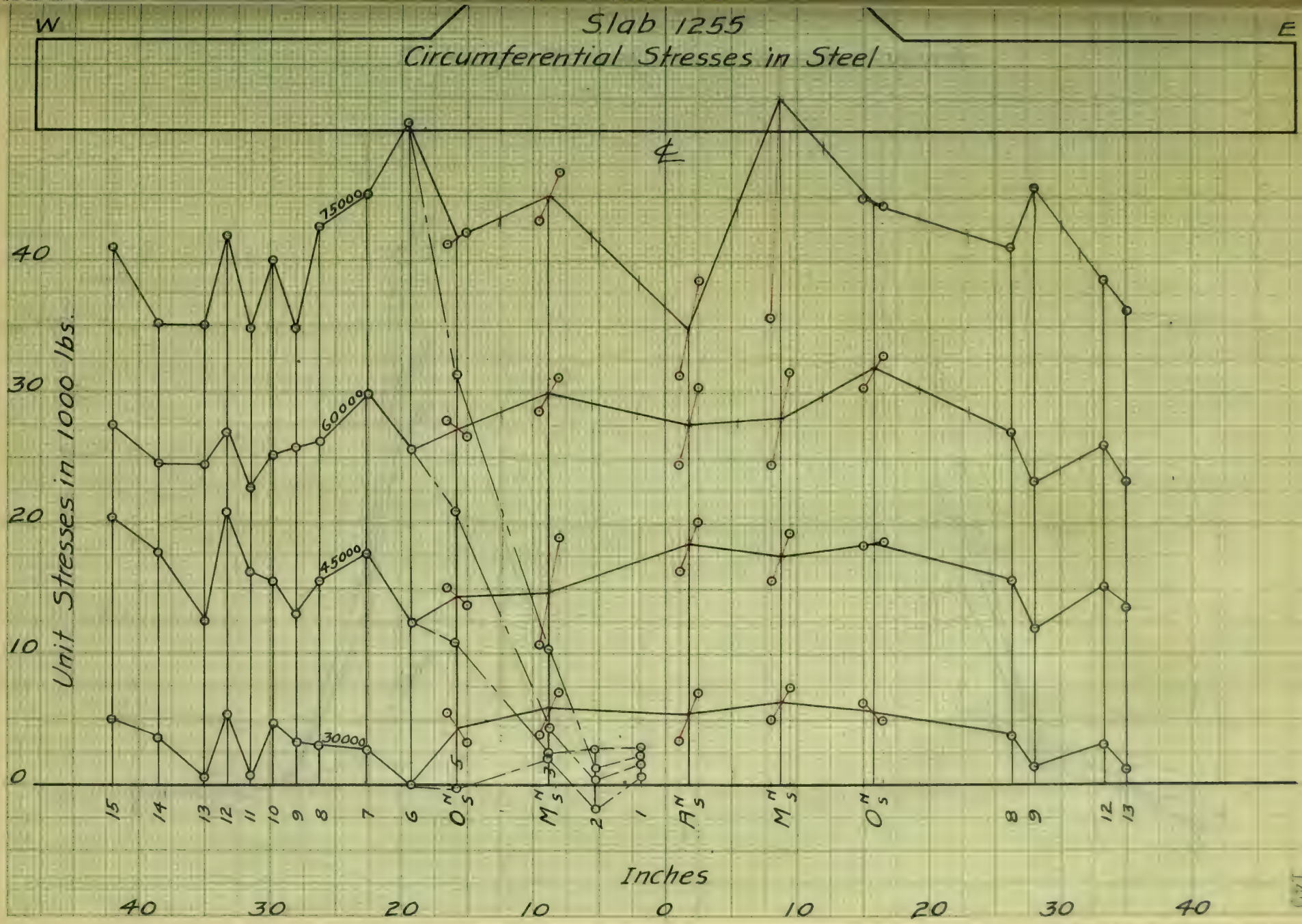


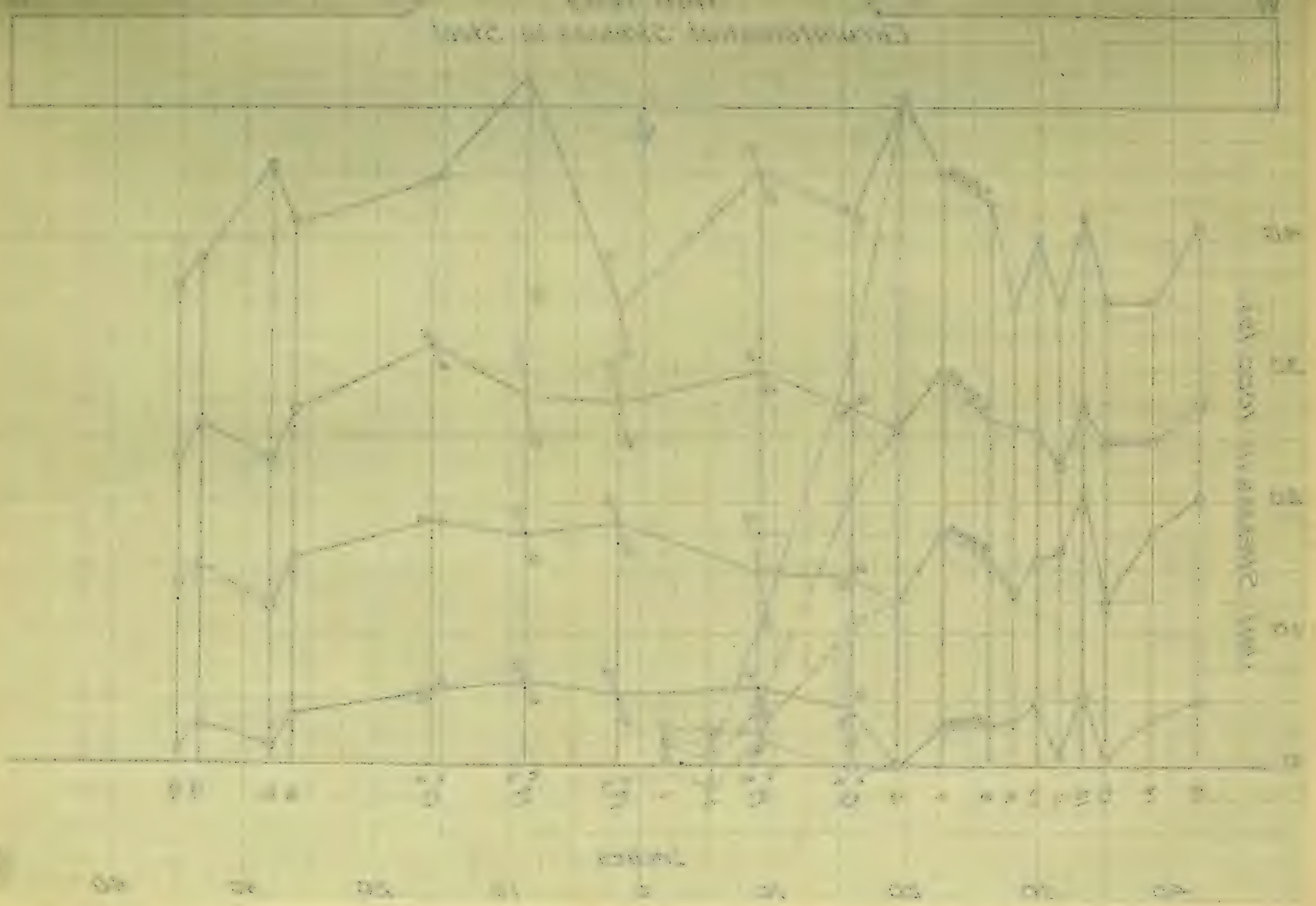

N-E
Slab-1255
S-W
Average Circumferential Stresses In Steel
75000
60000
45000
30000
40
30
20
10
0
Unit Stress in 1000 Lb.
Inches
40
30
20
10
0
10
20
30
40

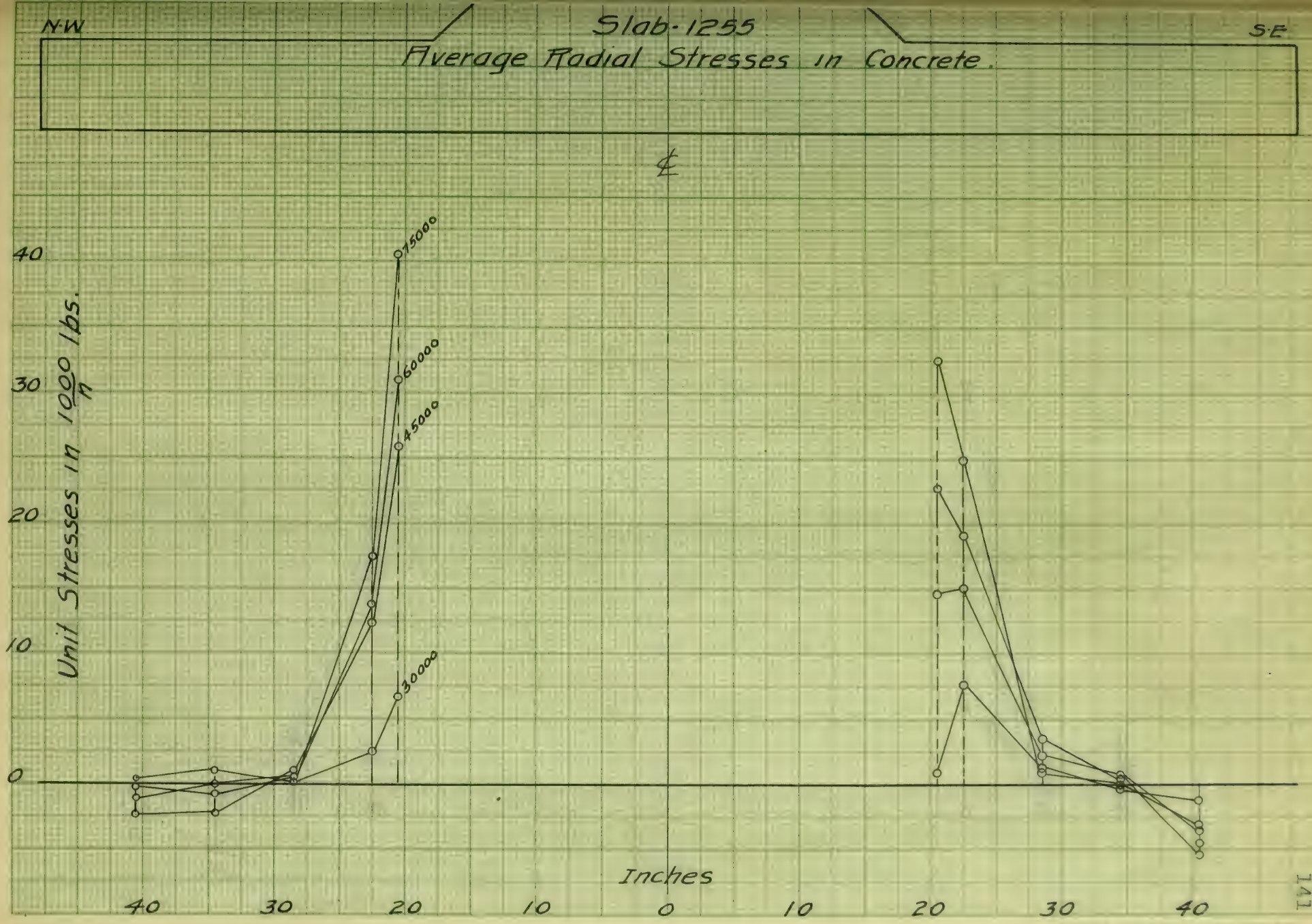


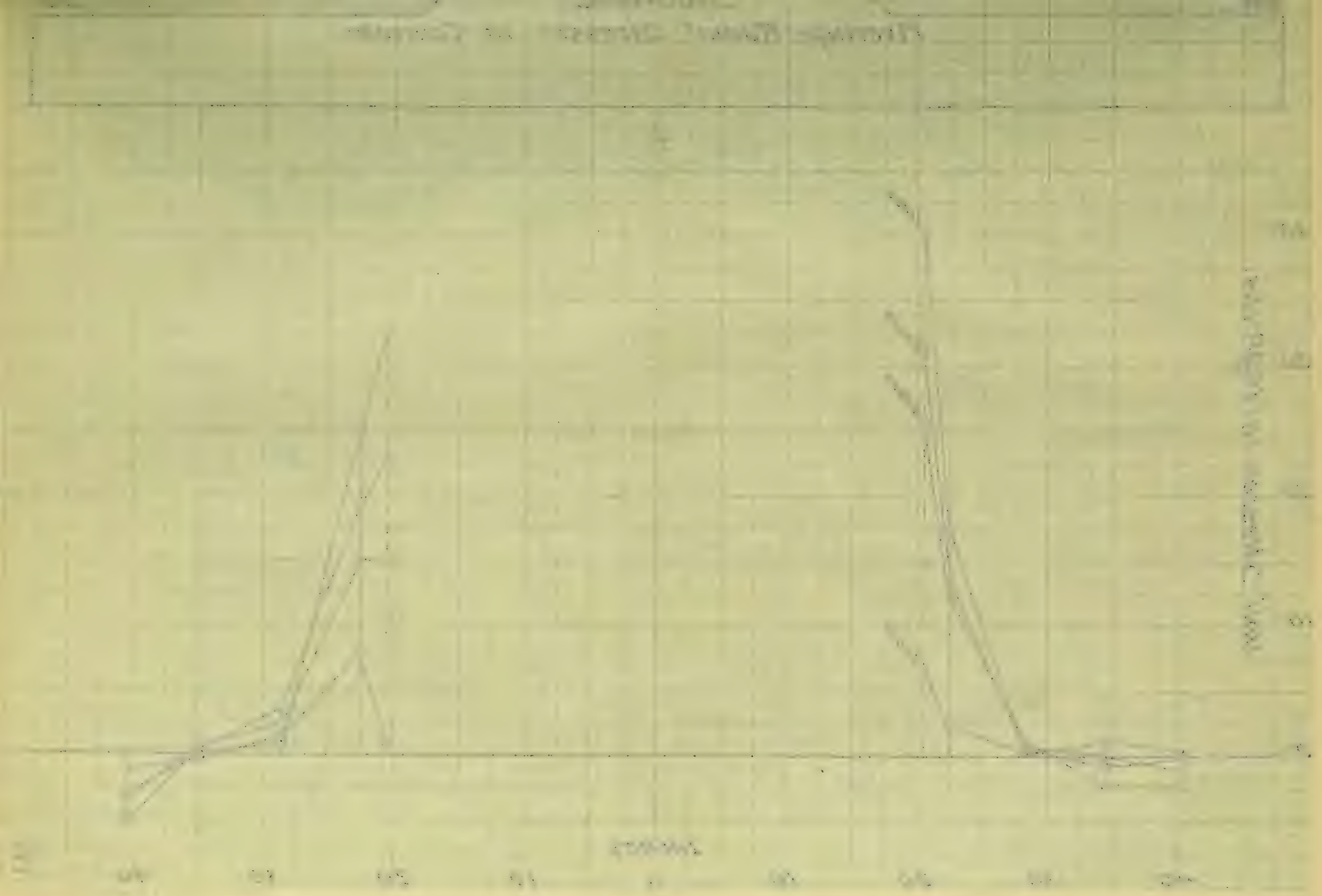

N
S
Slab-1255
Circumferential Stresses in Steel
℄
75000
60000
45000
30000
Unit Stresses in 1000 lbs.
40
30
20
10
0
15
13
12
9
8
6
H E W
P E W
A E W
P E W
H E W
6
8
9
13
Inches
40
30
20
10
0
10
20
30
40

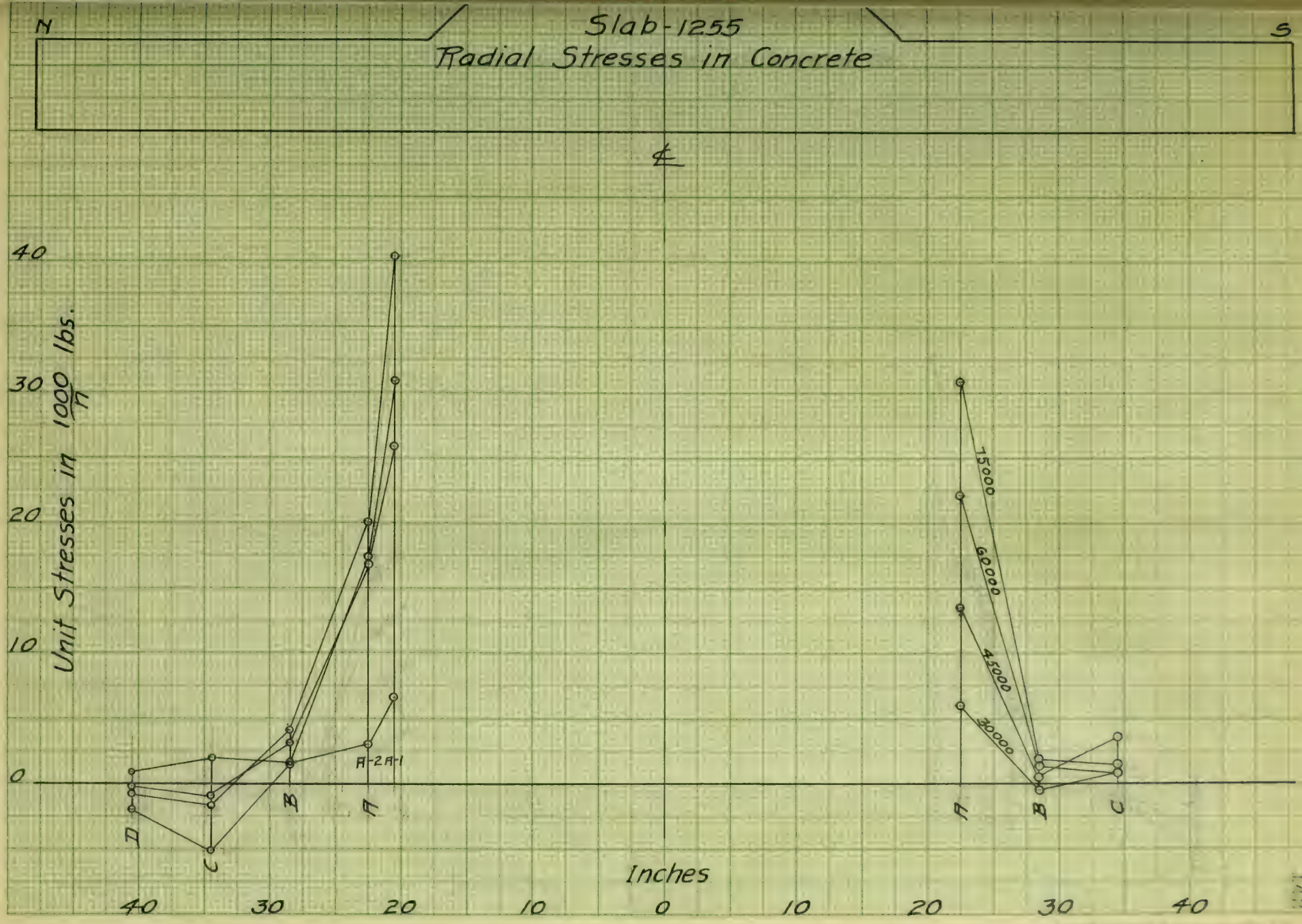


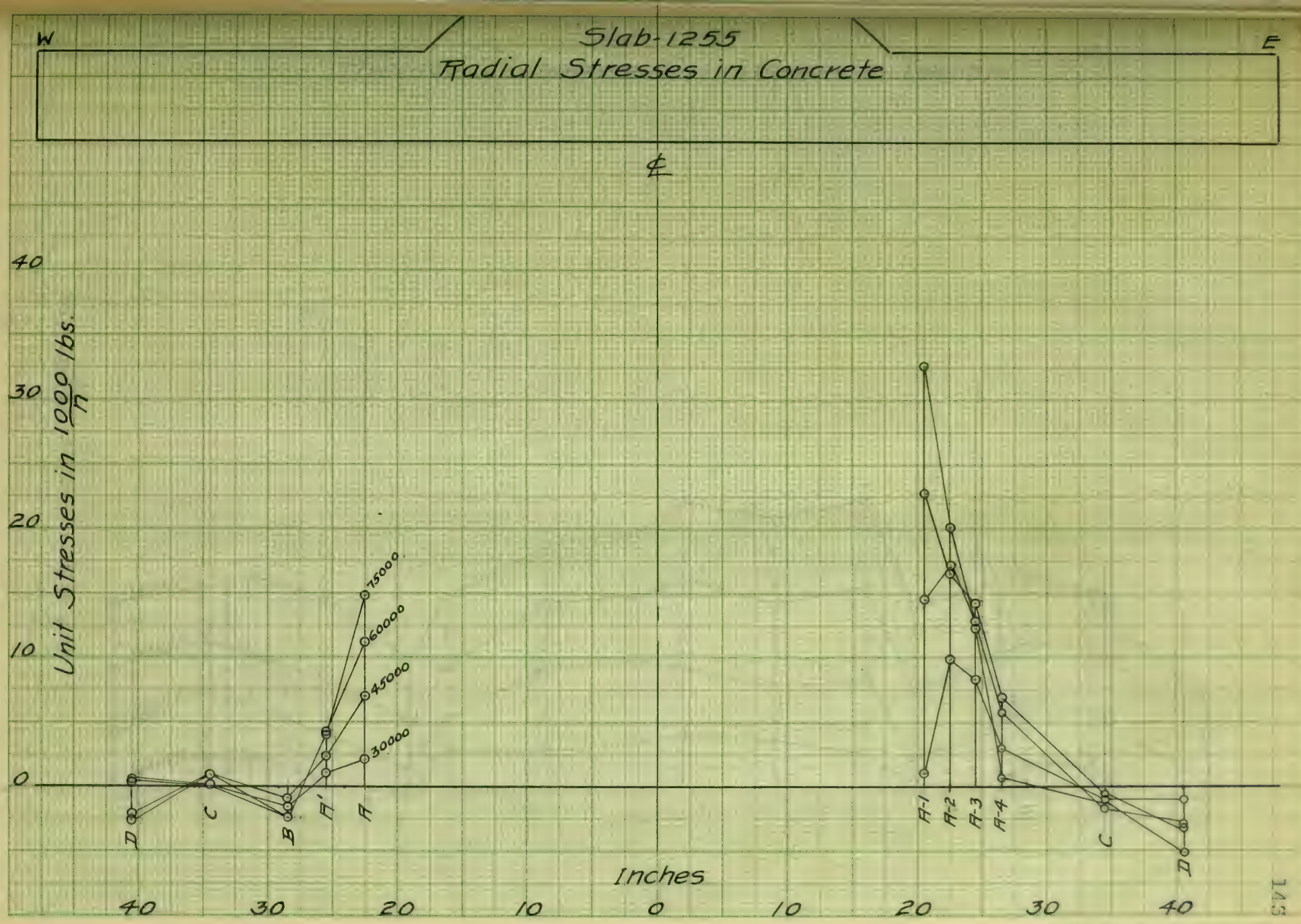

W
Slab 1255
Circumferential Stresses in Steel
E
℄
75000
60000
45000
30000
40
30
20
10
0
Unit Stresses in 1000 lbs.
15
14
13
12
11
10
9
8
7
6
O N S
5
M N S
3
2
1
A N S
M N S
O N S
8
9
12
13
Inches
40
30
20
10
0
10
20
30
40

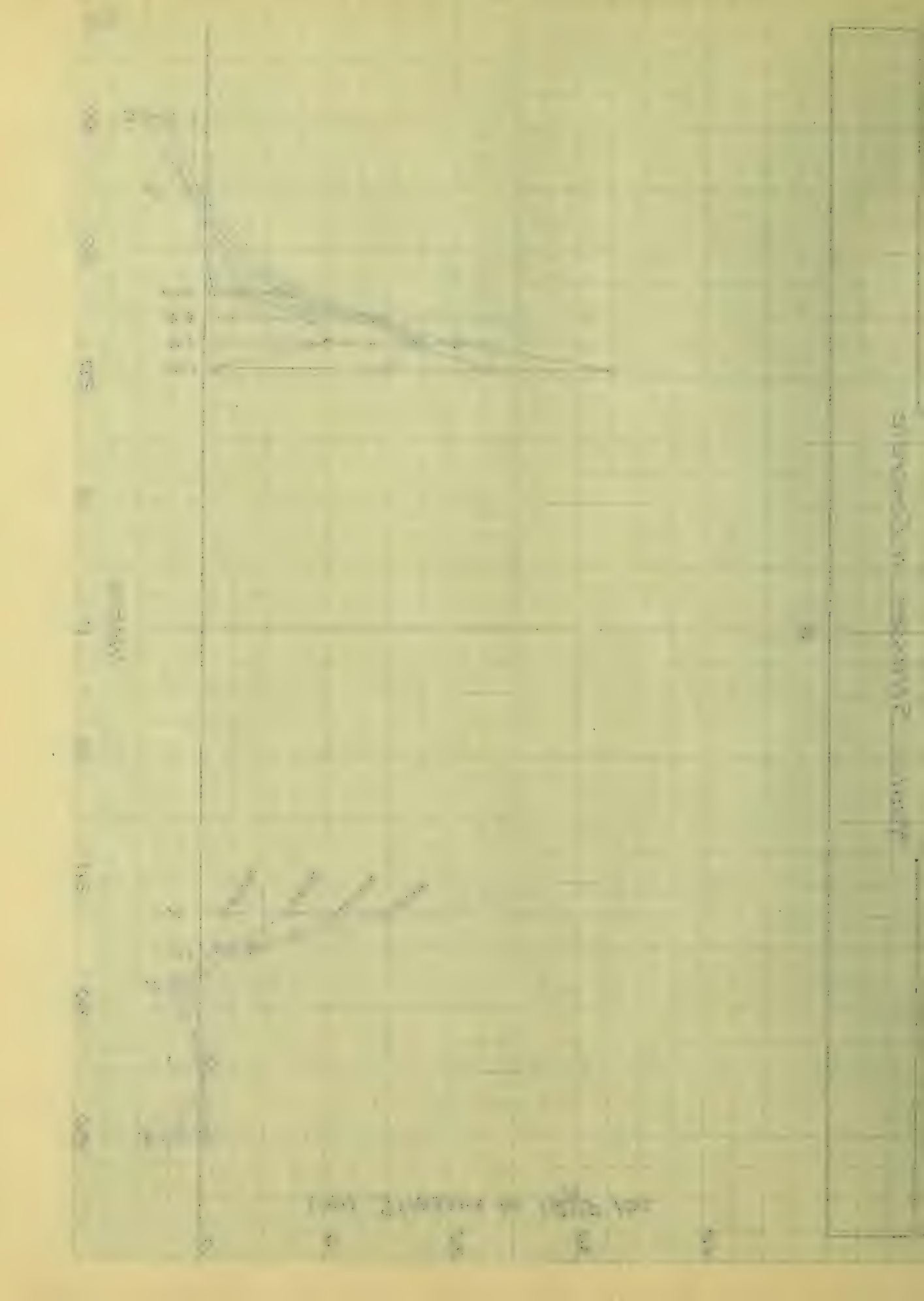


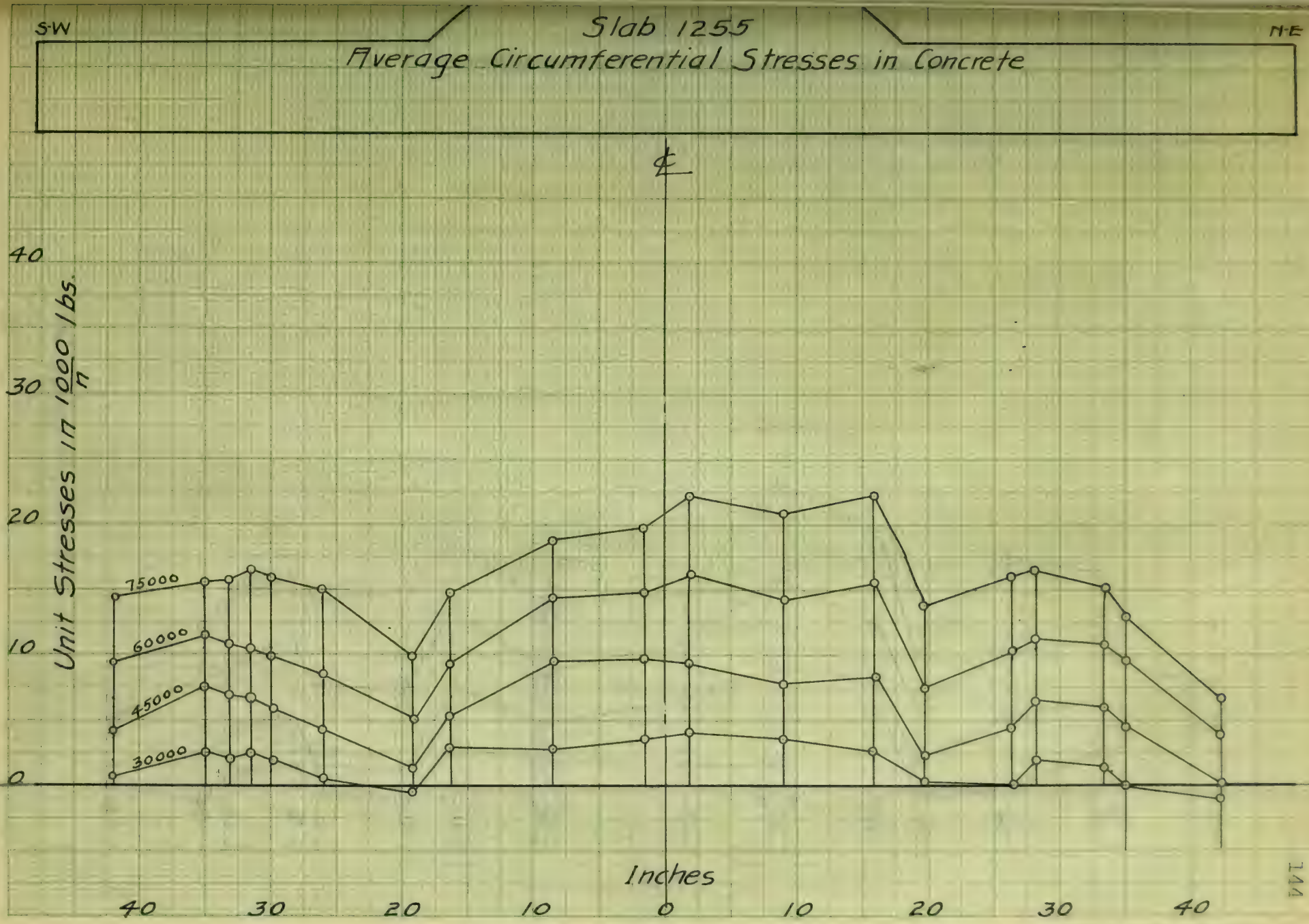

N.W
Slab-1255
Average Radial Stresses in Concrete.
S.E
℄
115000
60000
45000
30000
40
30
20
10
0
Unit Stresses in 1000 lbs. per sq. in.
Inches
40
30
20
10
0
10
20
30
40

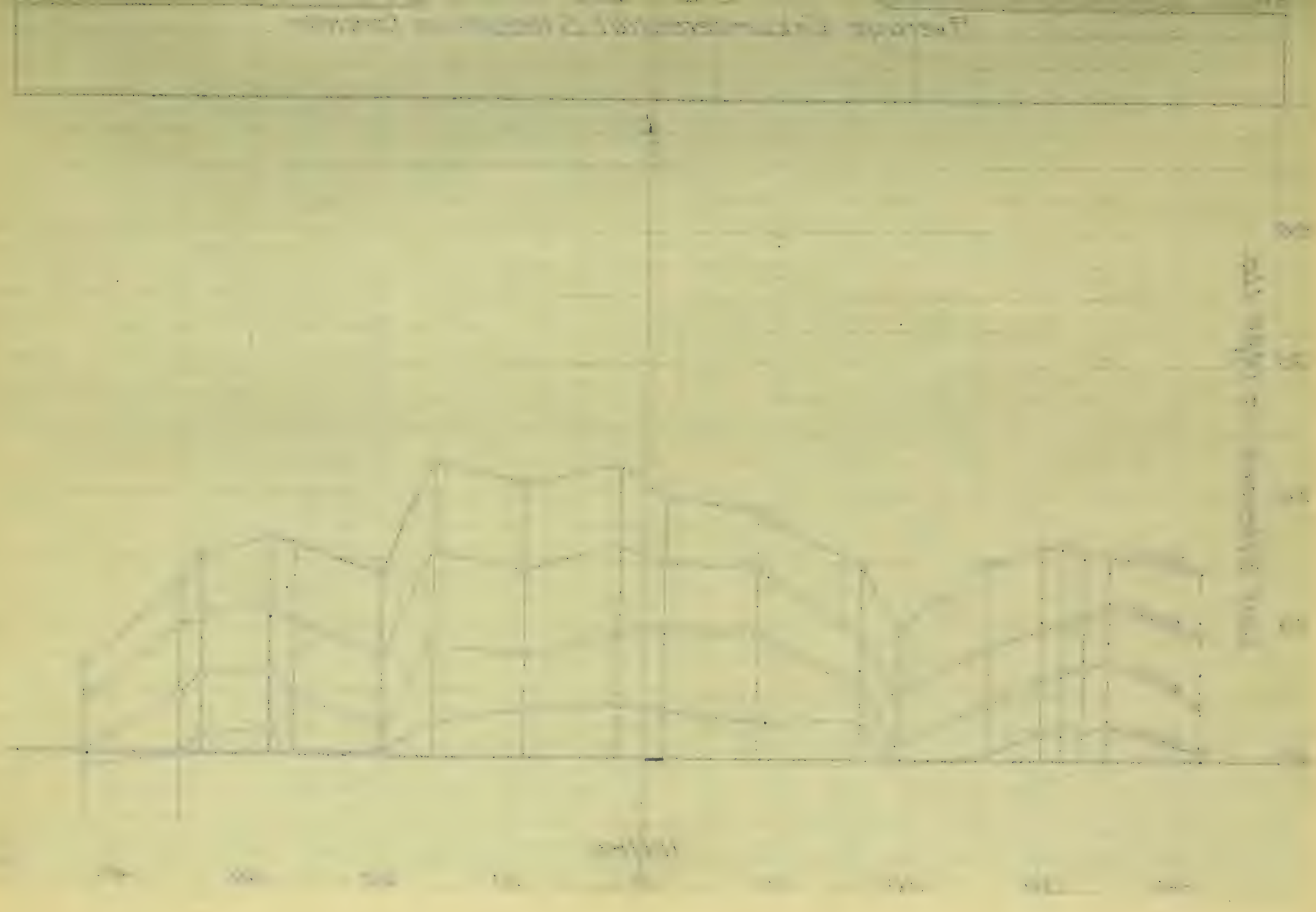


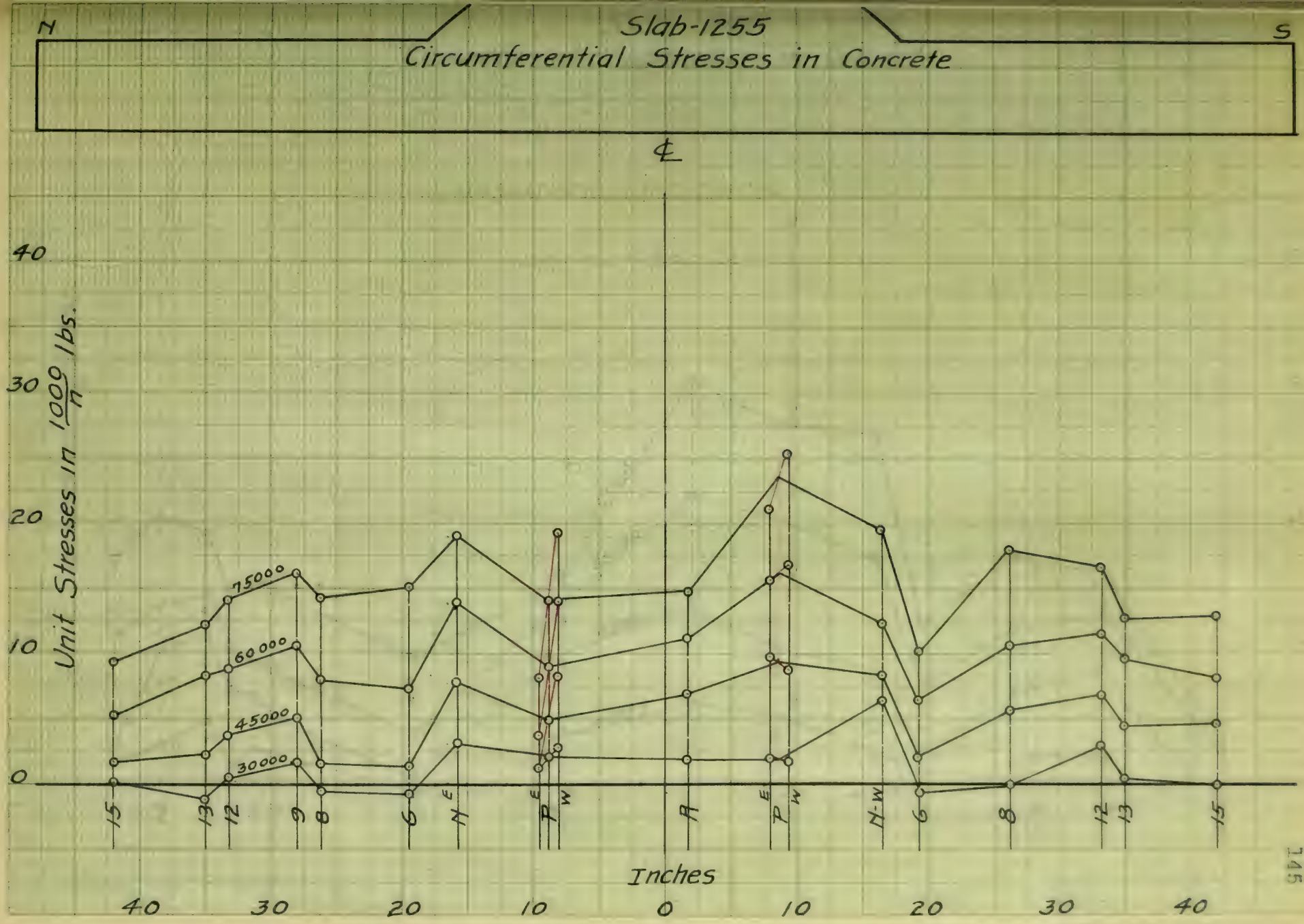

N
S
Slab-1255
Radial Stresses in Concrete
℄
40
30
20
10
0
Unit Stresses in 1000 lbs.
A
75000
60000
45000
30000
A-2
A-1
D
C
B
A
A
B
C
Inches
40
30
20
10
0
10
20
30
40


W
Slab-1255
Radial Stresses in Concrete
E
℄
40
30
20
10
0
Unit Stresses in 1000 lbs. per sq. in.
75000
60000
45000
30000
D
C
B
A'
A
A-1
A-2
A-3
A-4
C
D
Inches
40
30
20
10
0
10
20
30
40




S-W
Slab 1255
Average Circumferential Stresses in Concrete
N-E
℄
40
30
20
10
0
Unit Stresses in 1000 lbs. per sq. in.
75000
60000
45000
30000
Inches
40
30
20
10
0
10
20
30
40




N
Slab-1255
Circumferential Stresses in Concrete
S
℄
40
30
20
10
0
Unit Stresses in 1000/n lbs.
75000
60000
45000
30000
15
13
12
9
8
6
N E
P E
P W
A
A E
P W
N-W
6
8
12
13
15
Inches
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30
20
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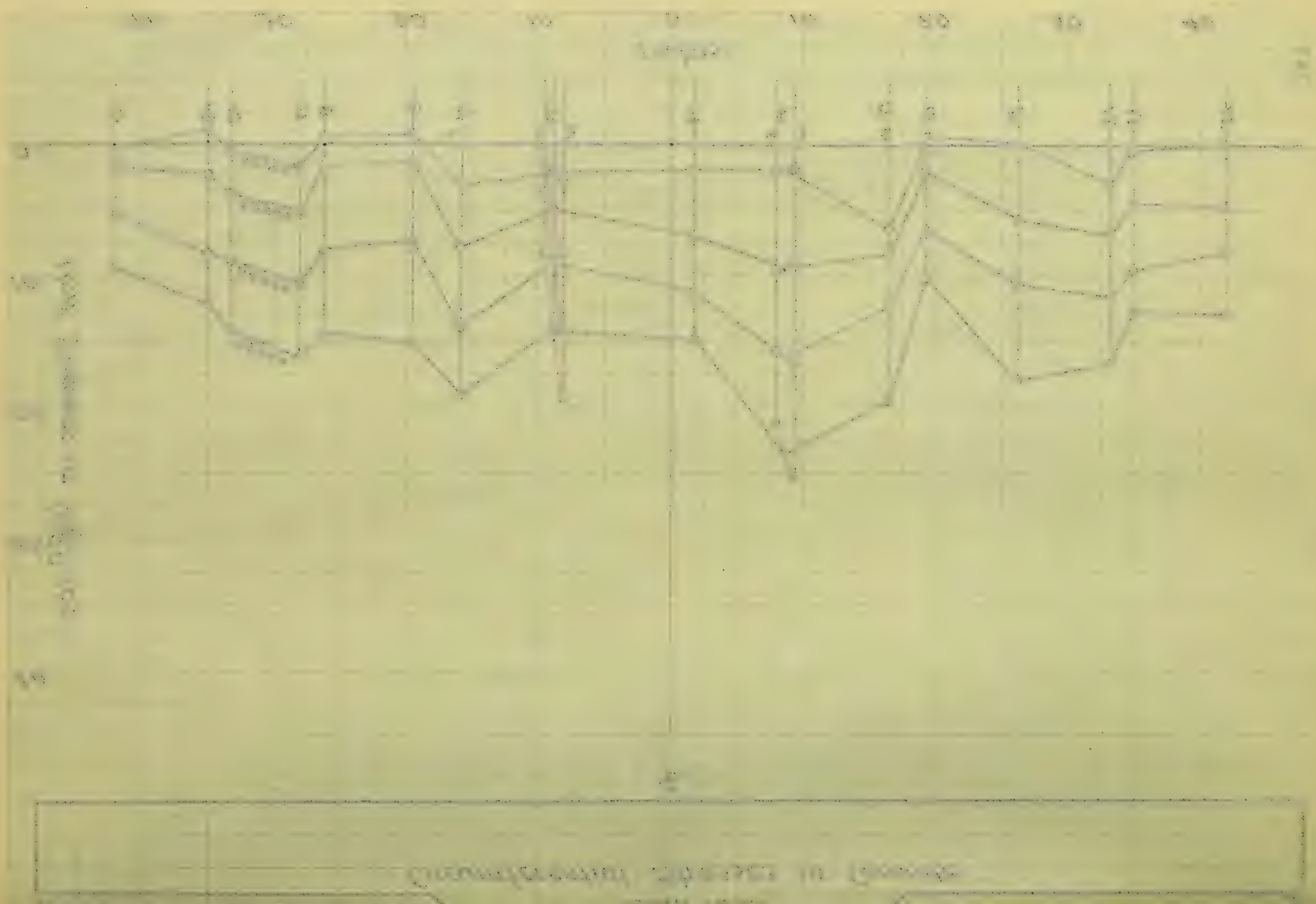
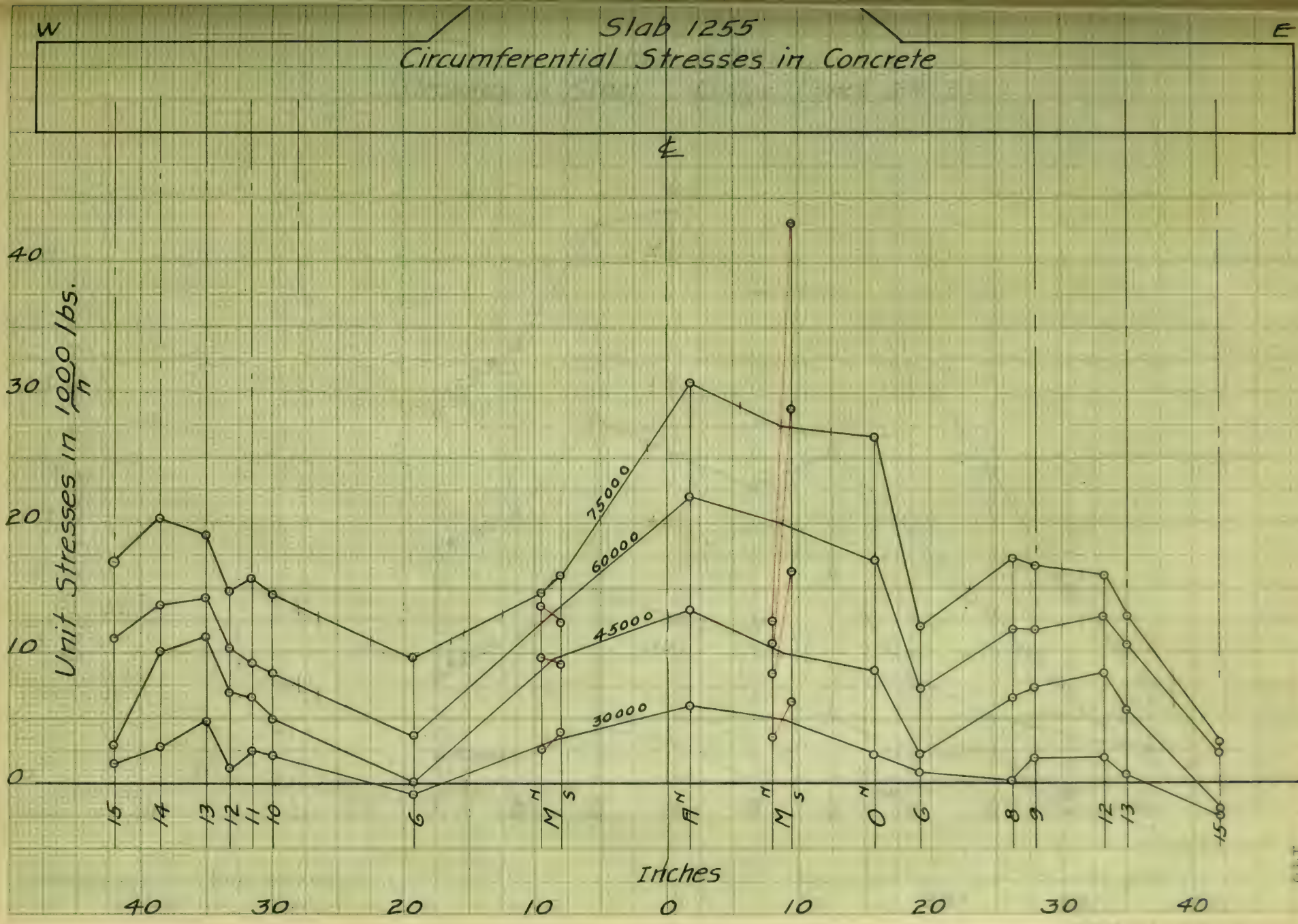
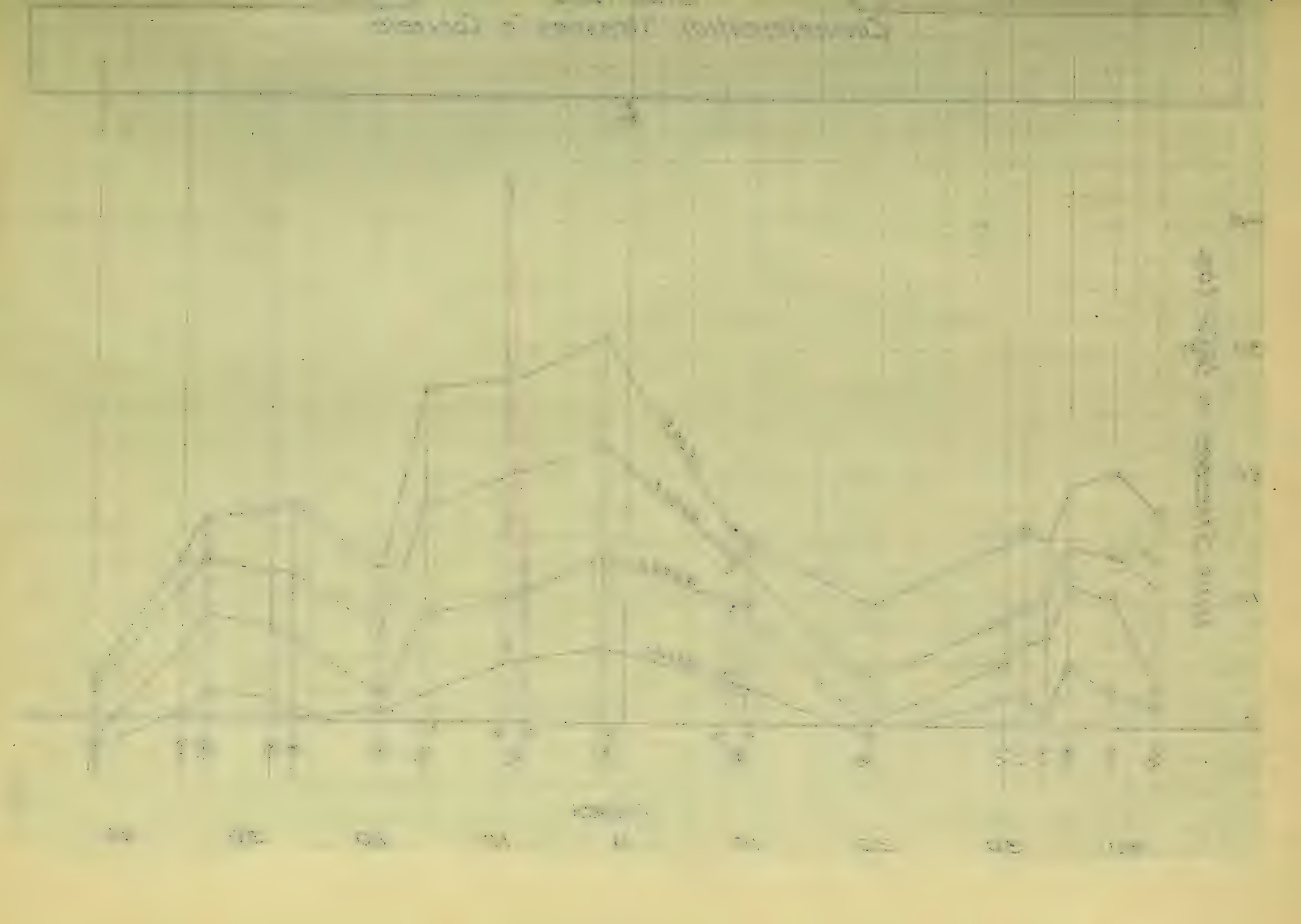
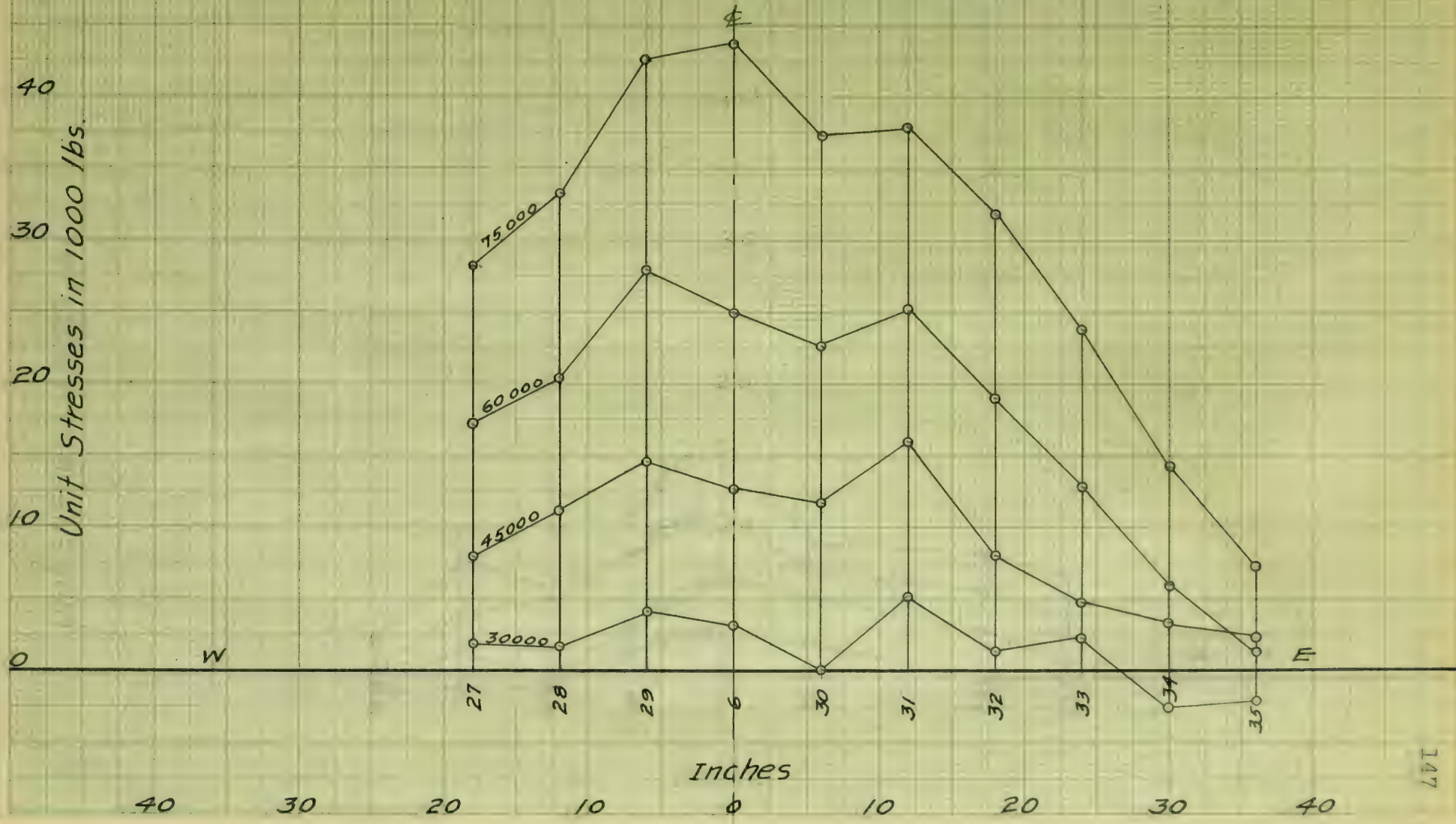
0
10
20
30
40

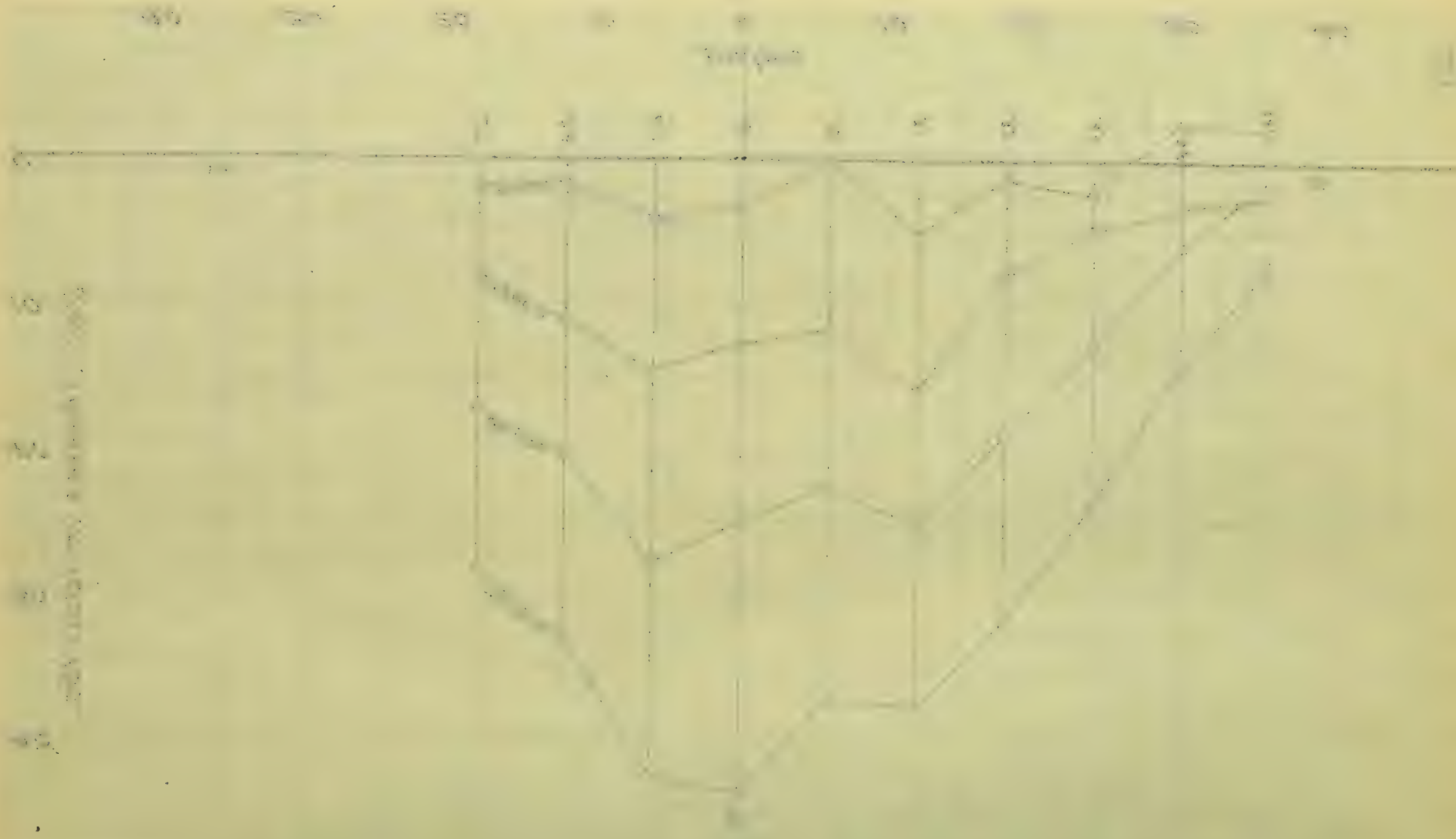



W
Slab 1255
Circumferential Stresses in Concrete
E
℄
40
30
20
10
0
Unit Stresses in 1000 lbs.
75000
60000
45000
30000
15
14
13
12
11
10
6
M N
M S
A N
M S
O N
6
8
9
12
13
45
Inches
40
30
20
10
0
10
20
30
40



Slab-1255
Stresses in Steel. Gage Lines 24-35

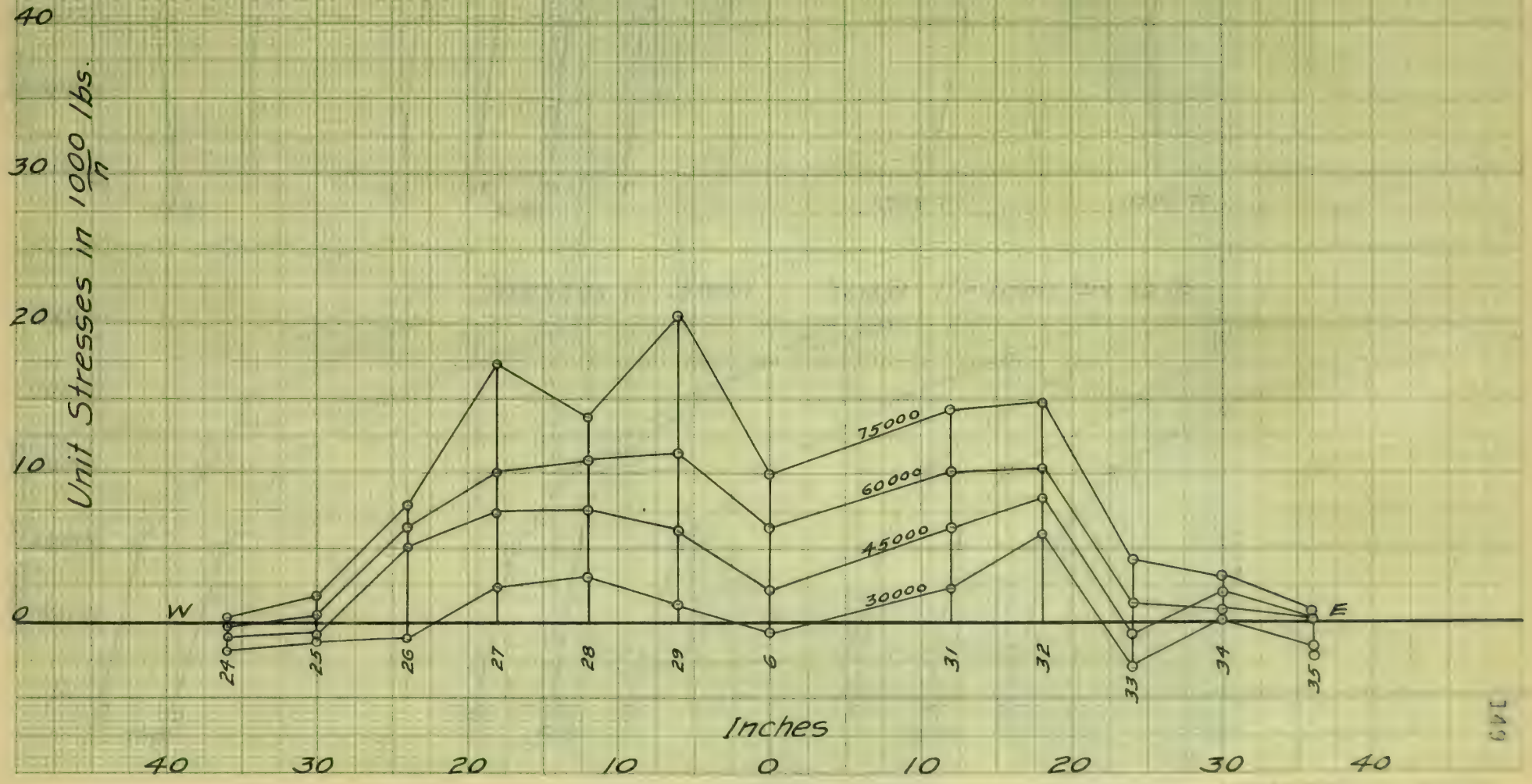


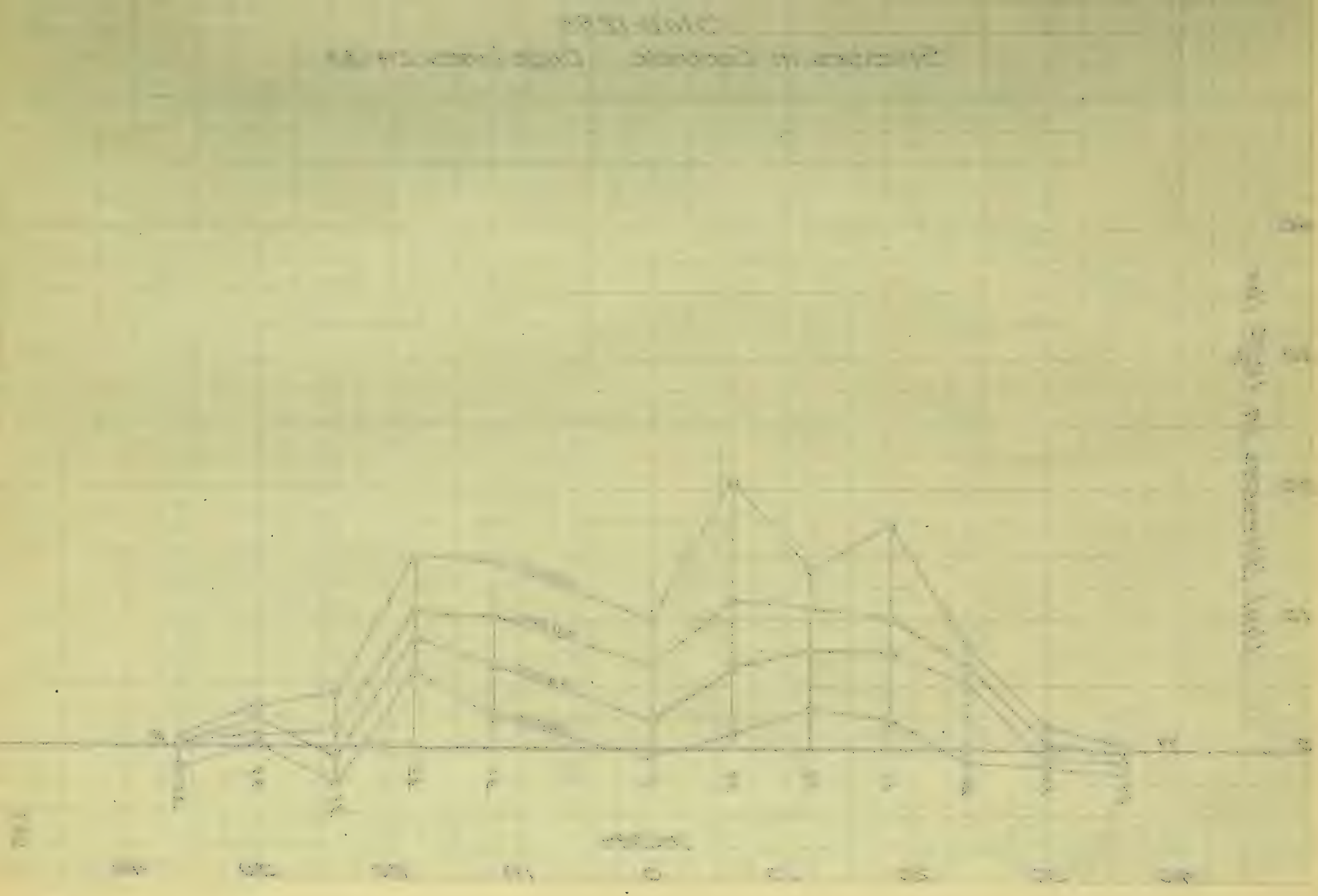


Slab 1255

Stresses in Concrete Gage Lines 16-23

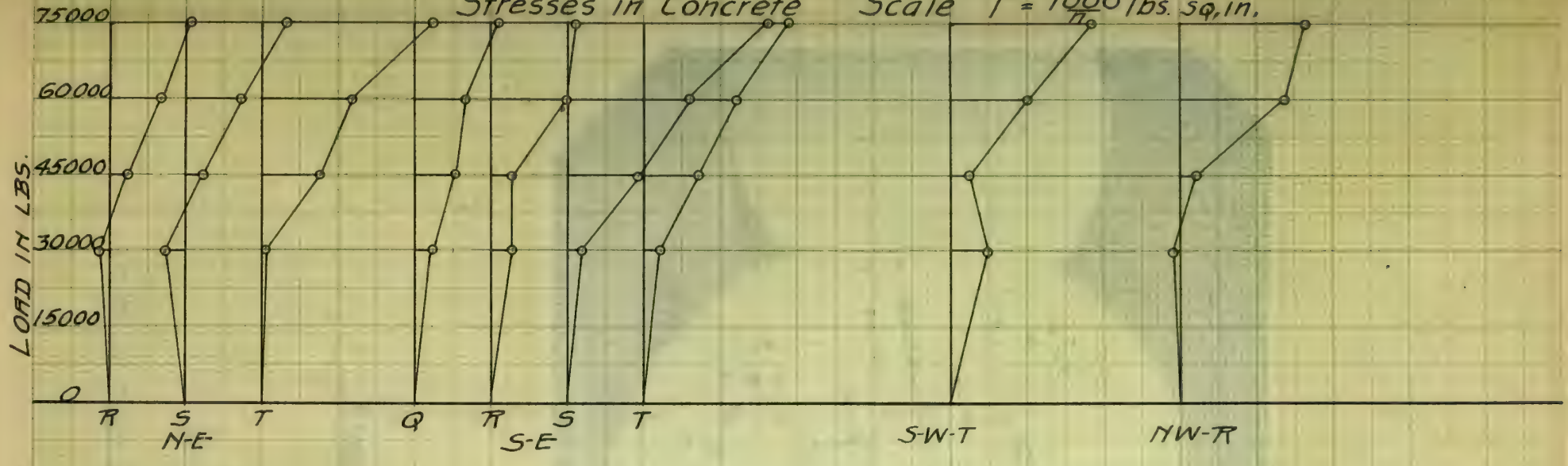
Slab-1255
Stresses in Concrete. Gage Lines 24-35



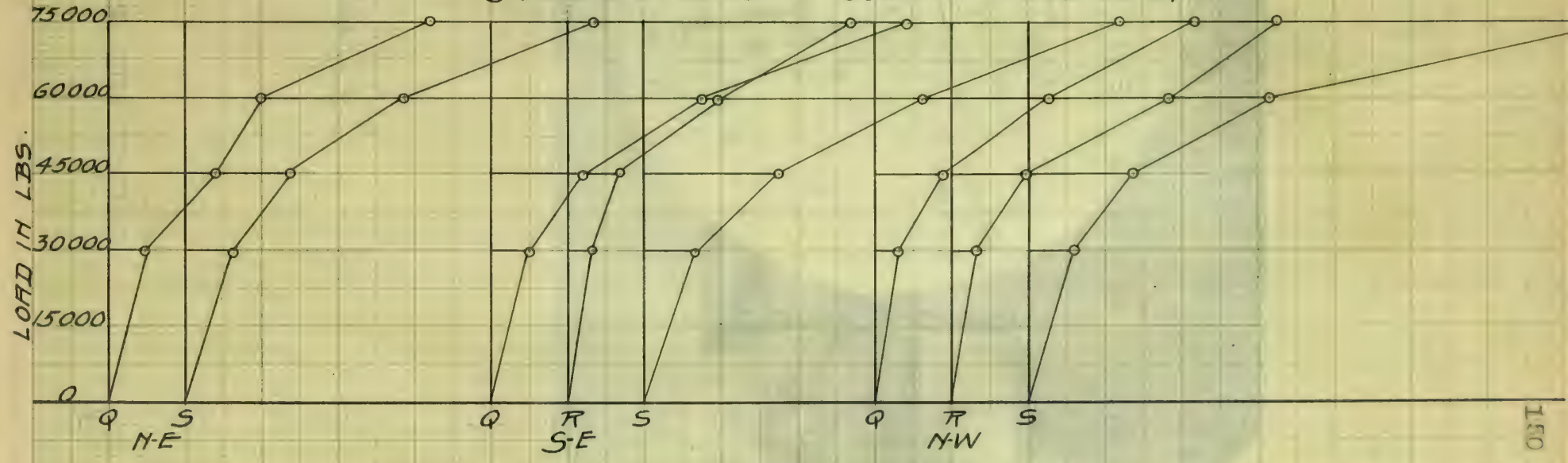


Gage Lines on Slab-1255.

Stresses in Concrete Scale 1" = 1000 lbs. sq. in.



Stresses in Steel Scale 1" = 1000 lbs. sq. in.



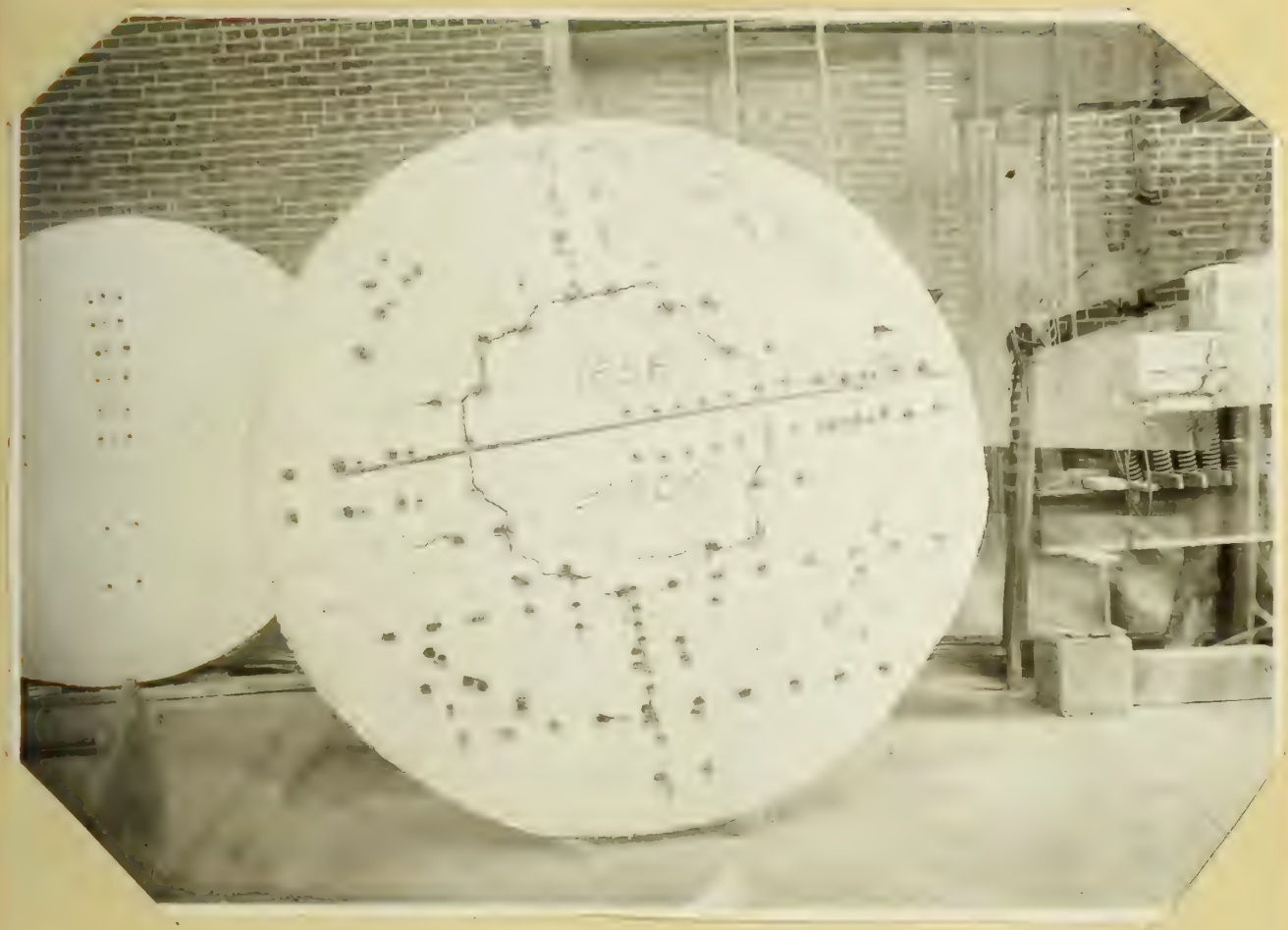
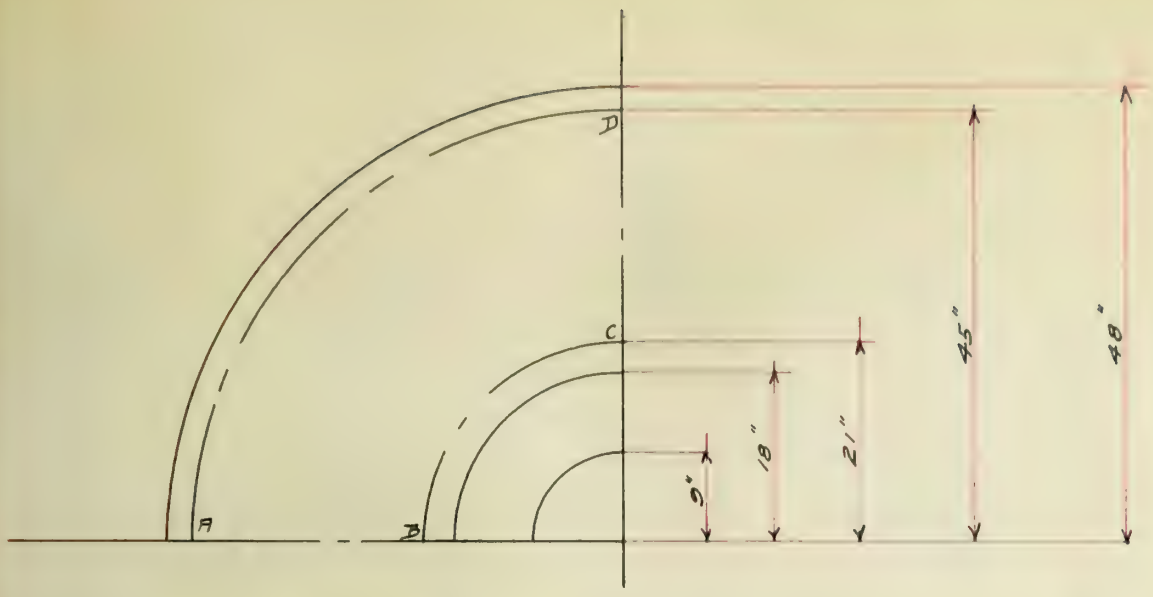


Figure 29.

VIEW OF SCAR # 1256 AFTER TESTING.



Slab 1256. Equilibrium Calculations.

The bending moment equals $.707\left(\frac{45-21}{4}\right)$ 60000 or 255000 inch pounds, in the direction CD on the section ABC. (W=60000#)

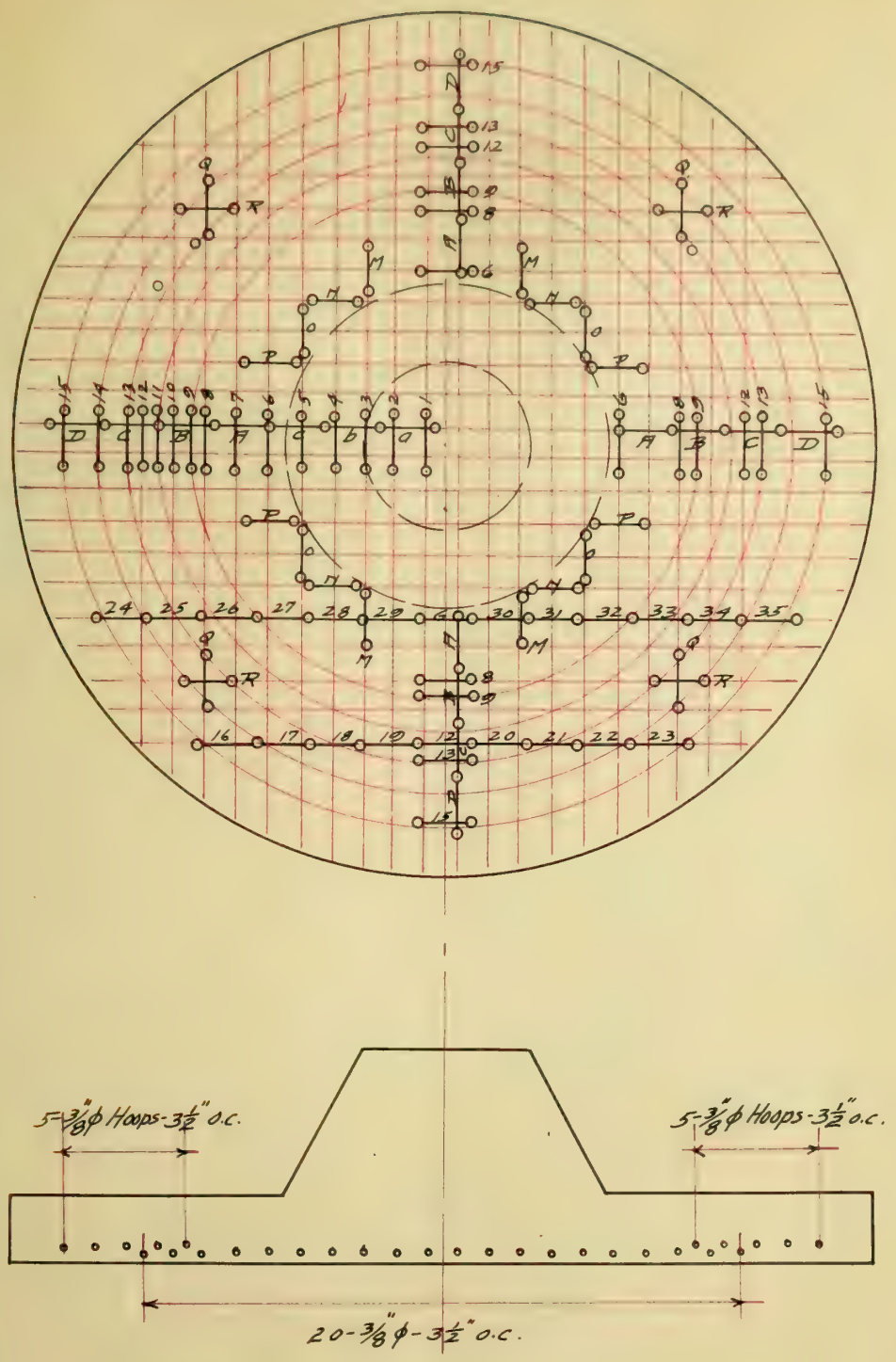
14 - 3/8 inch diam. rods cut the section.

A_s equals 1.65 sq. inches.

The average steel stress for the load of 60000 pounds equals 27500 pounds per sq. inch, on all the rods cutting the section ABC in the direction CD.

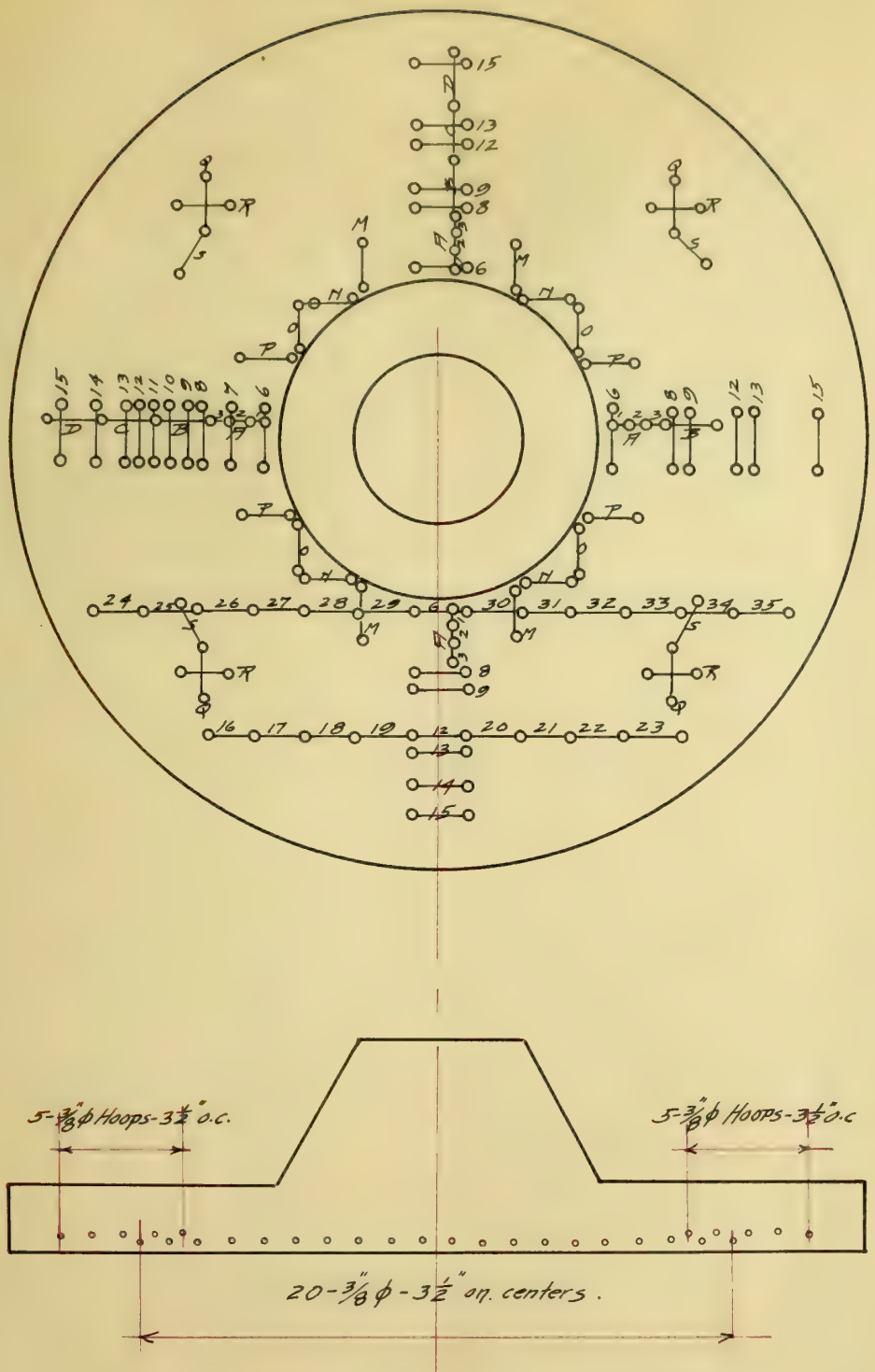
Therefore the effective depth or jD becomes

255000/ 1.65(27500) or 5.63 inches.



Gage Lines in the Steel. Slab 1256

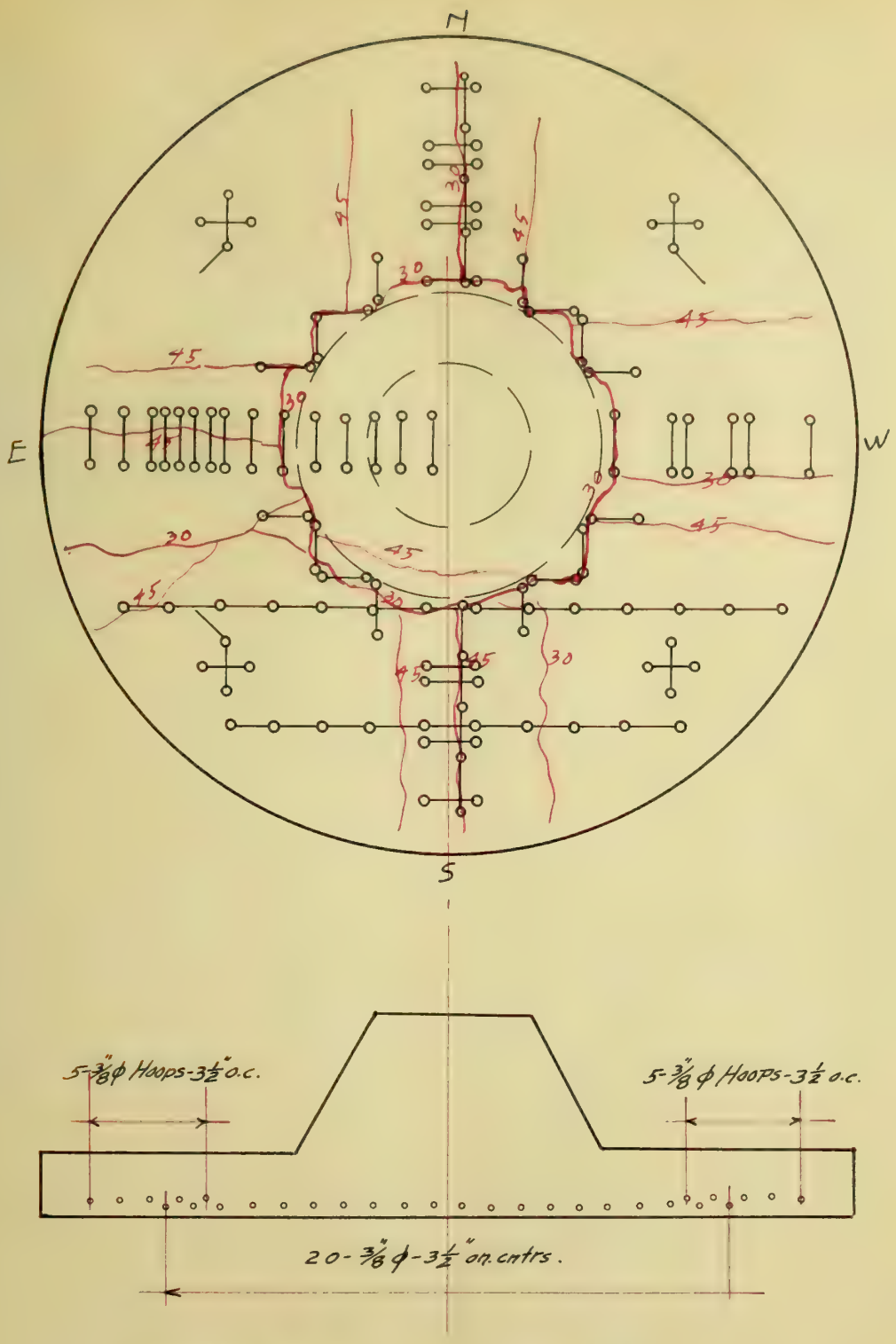
Figure 30.



Gage Lines in the Concrete.

Slab 1256

Figure 31.

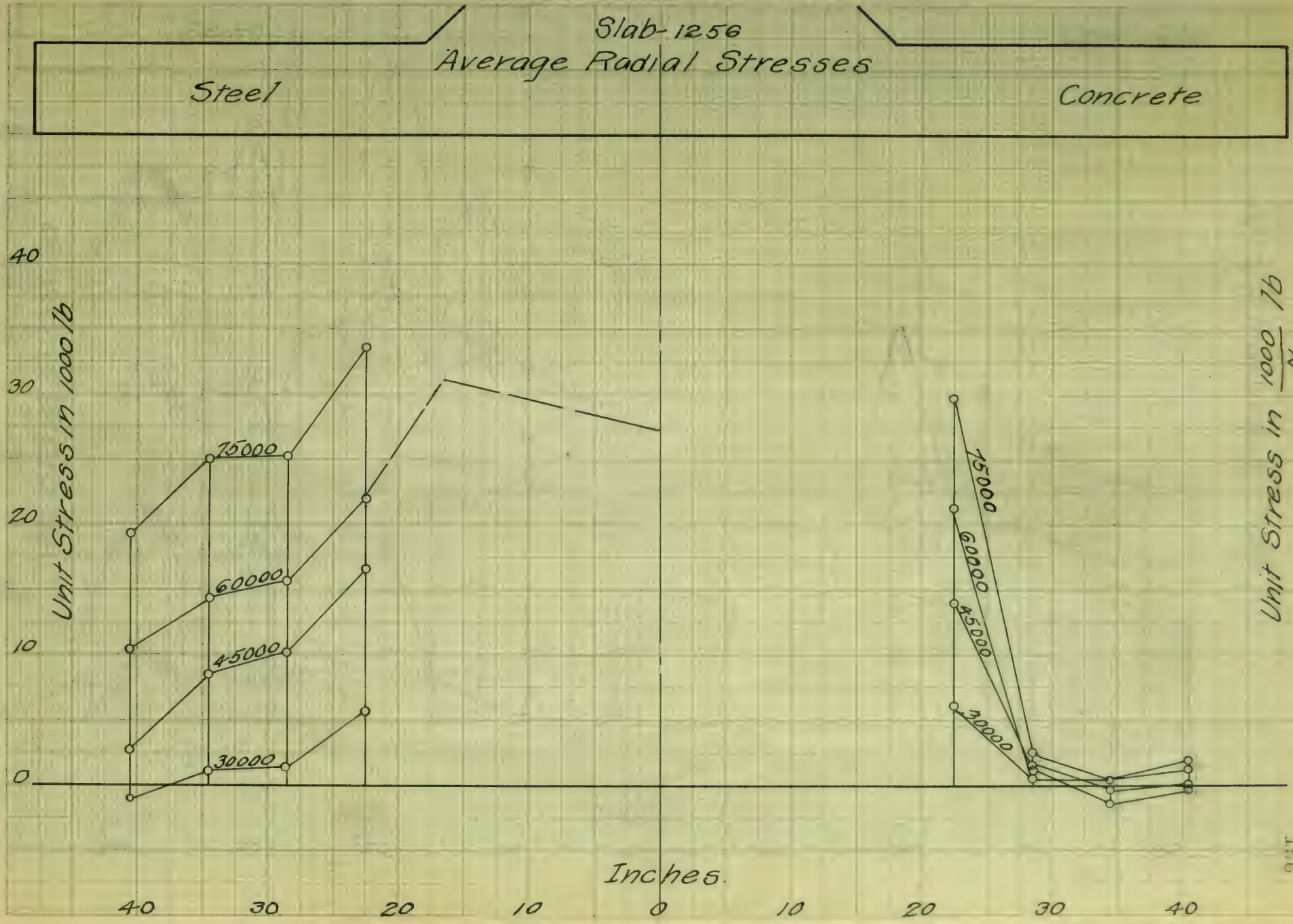


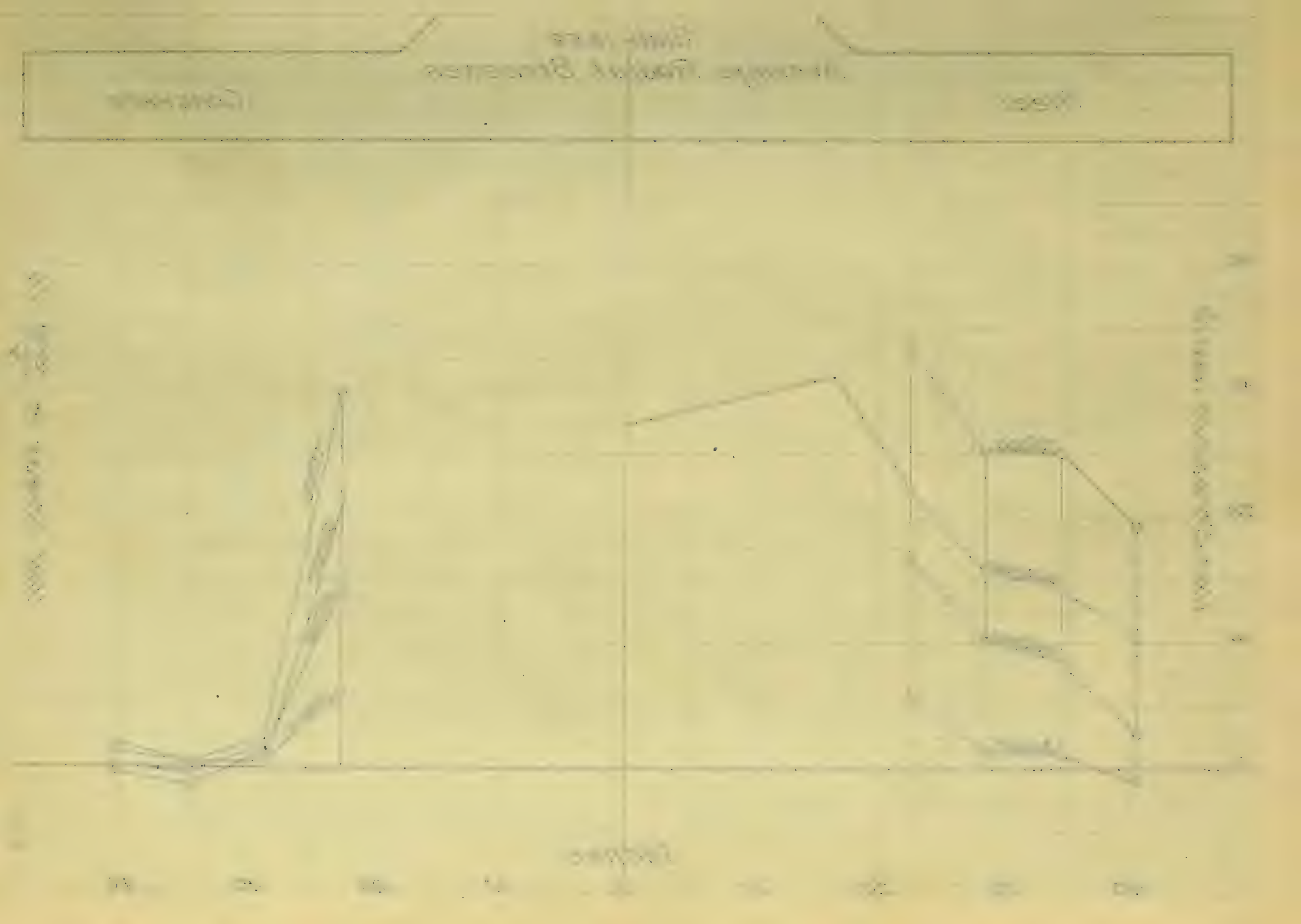
Sketch of cracks. Slab 1256.

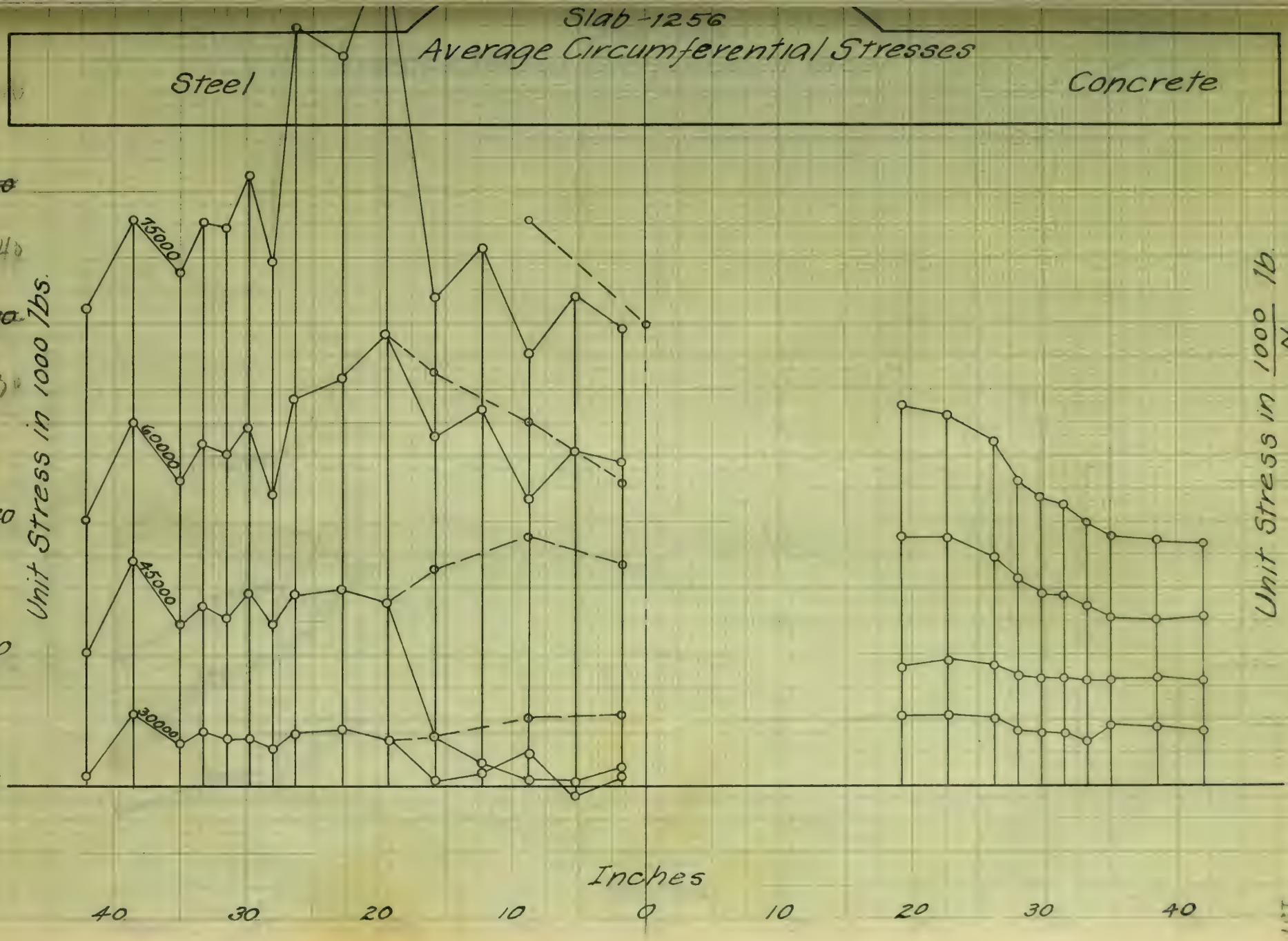
Figure 32.

Slab-1256

Average Radial Stresses



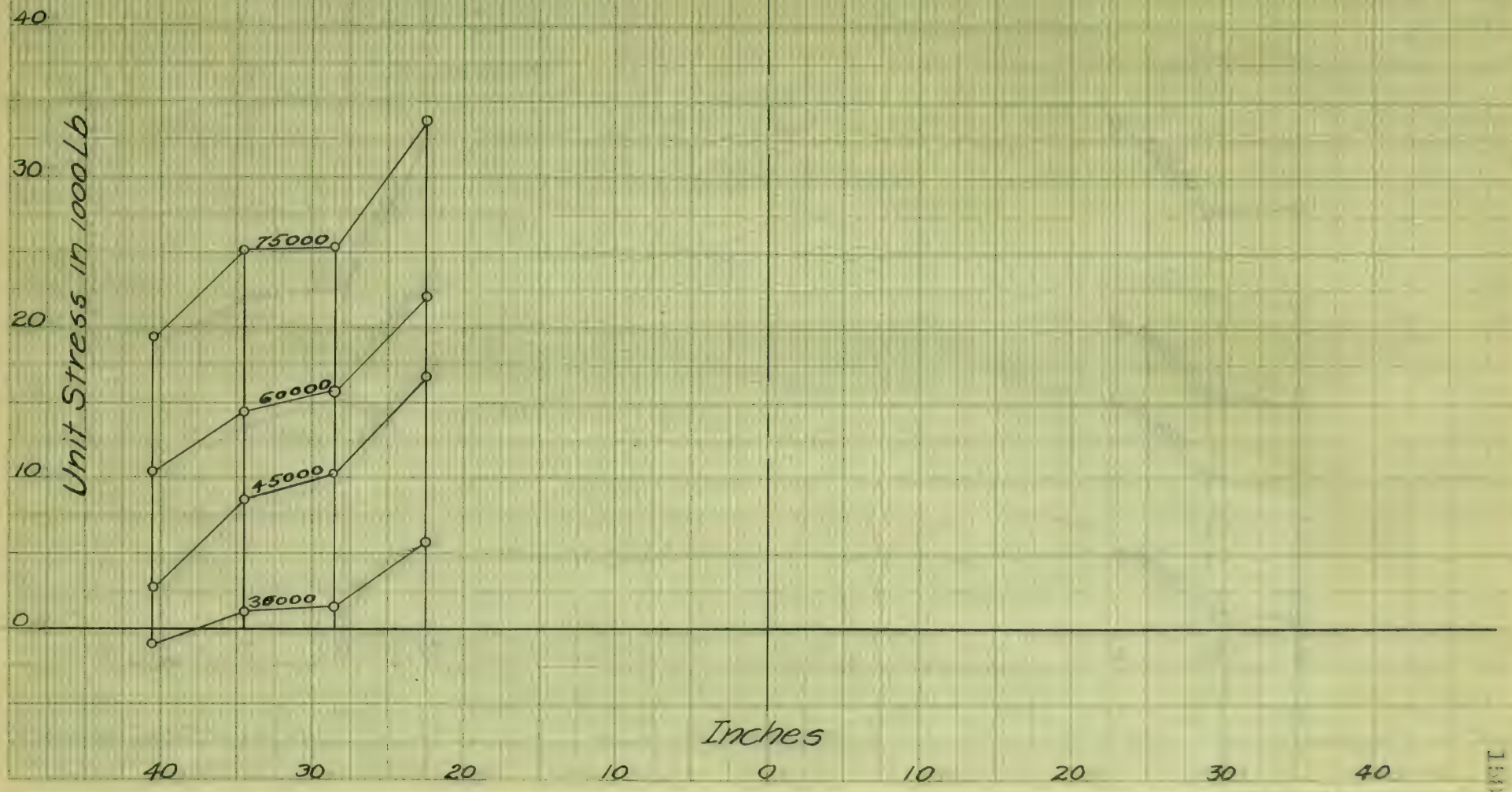


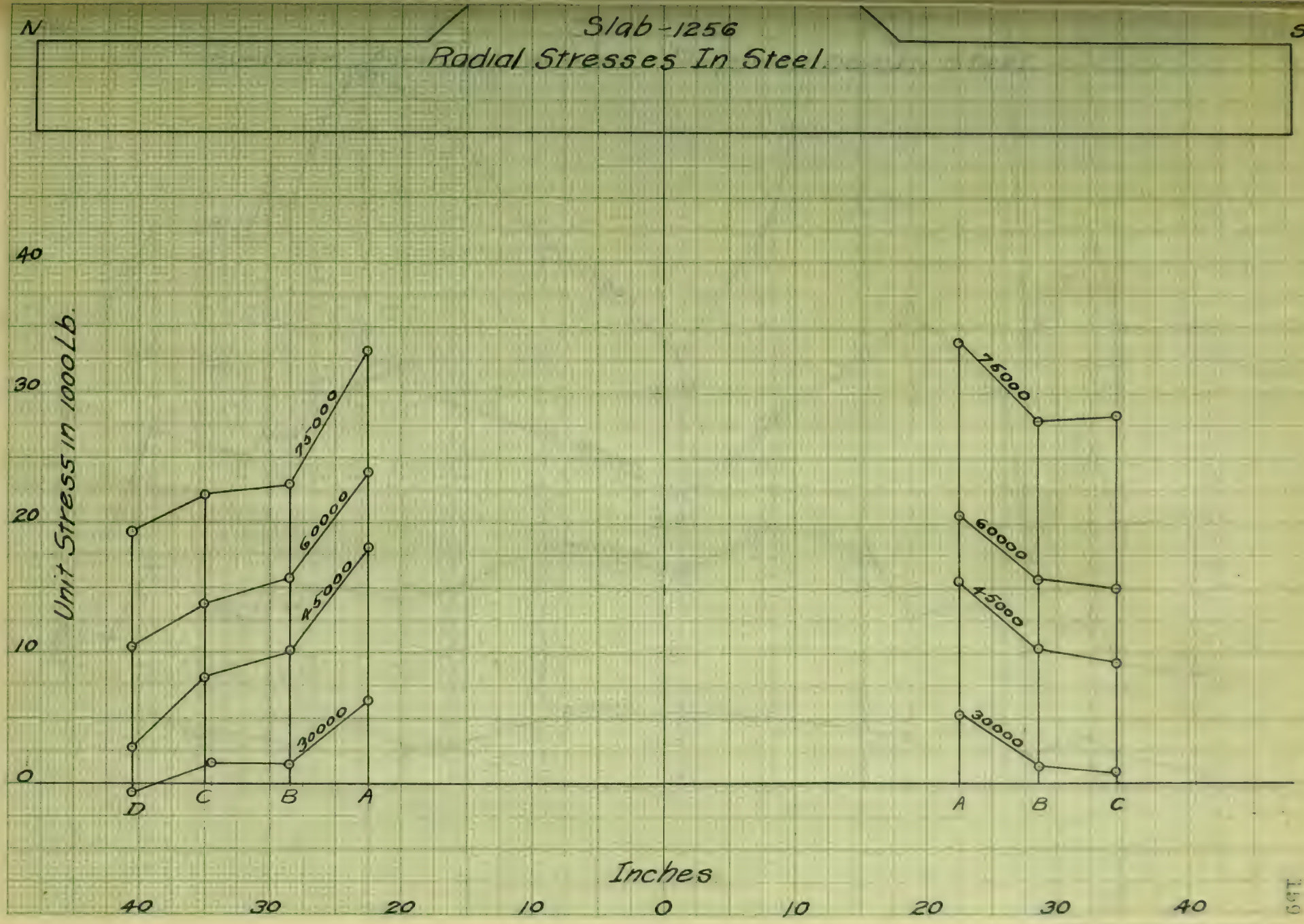

Slab -1256
Average Circumferential Stresses
Steel
Concrete
Unit Stress in 1000 lbs.
Unit Stress in 1000 / N lb.
15000
60000
45000
30000
40
30
20
10
0
Inches
40
30
20
10
0
10
20
30
40

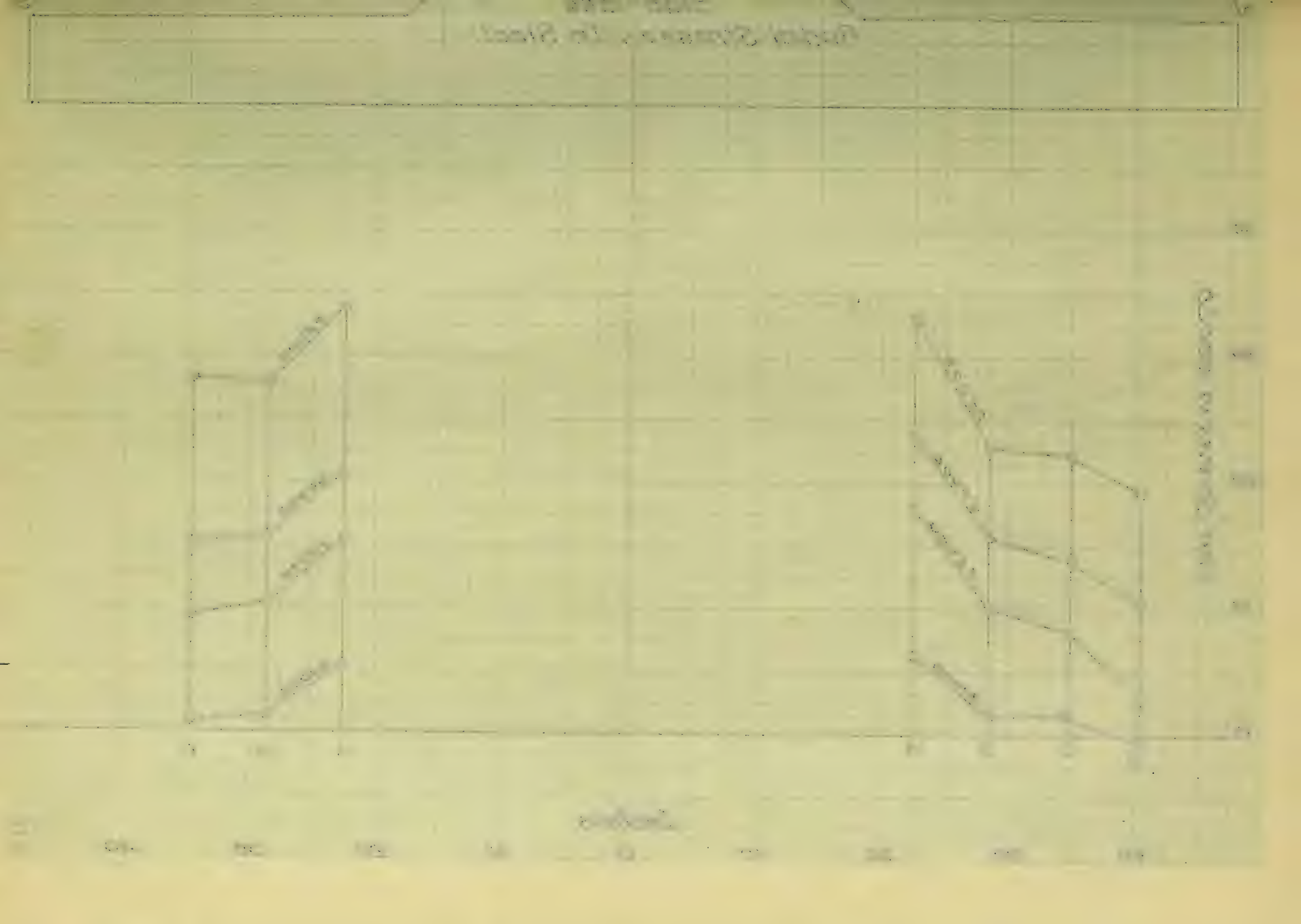
11

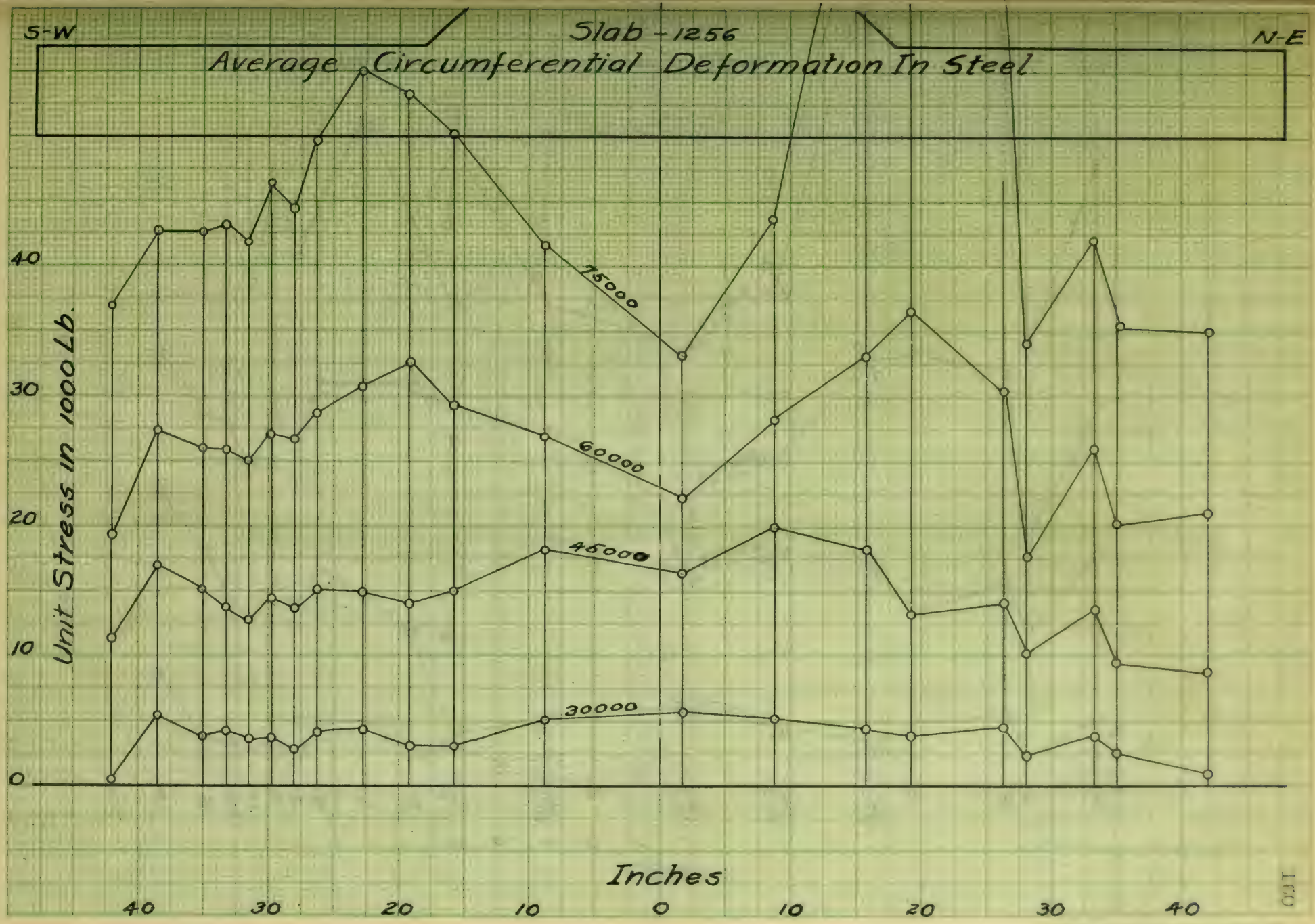
Slab+1256

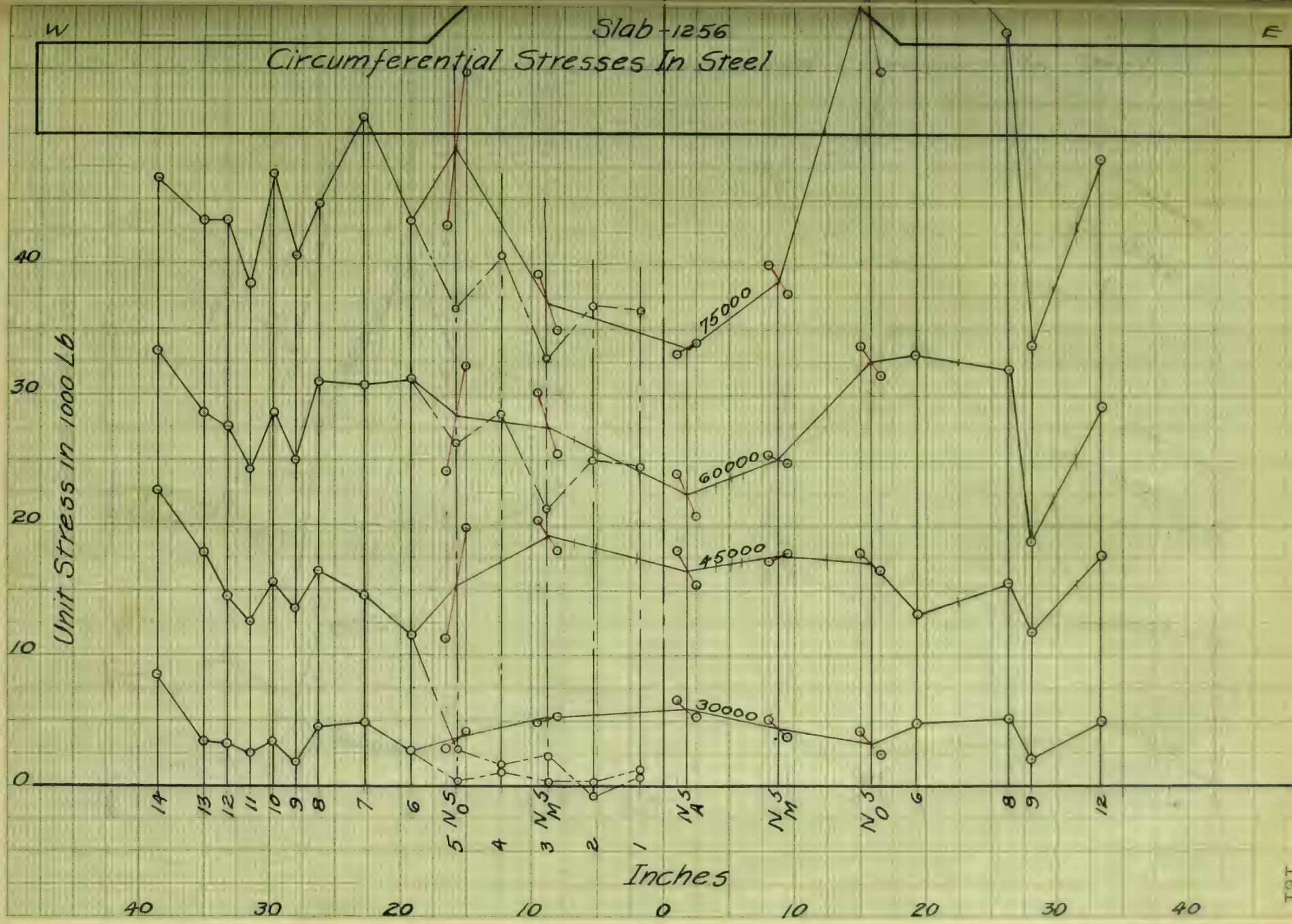
Average Radial Stresses In Steel

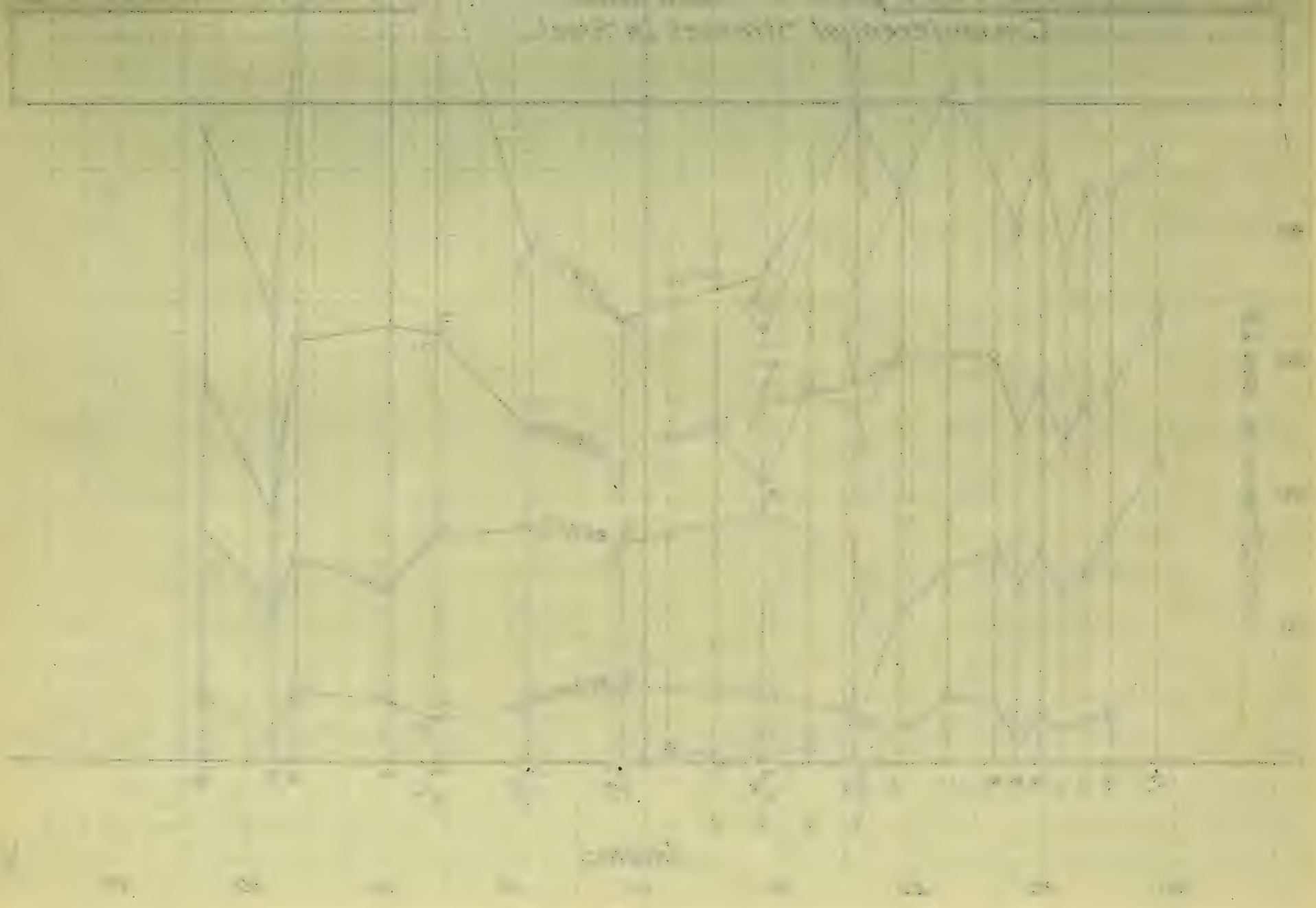


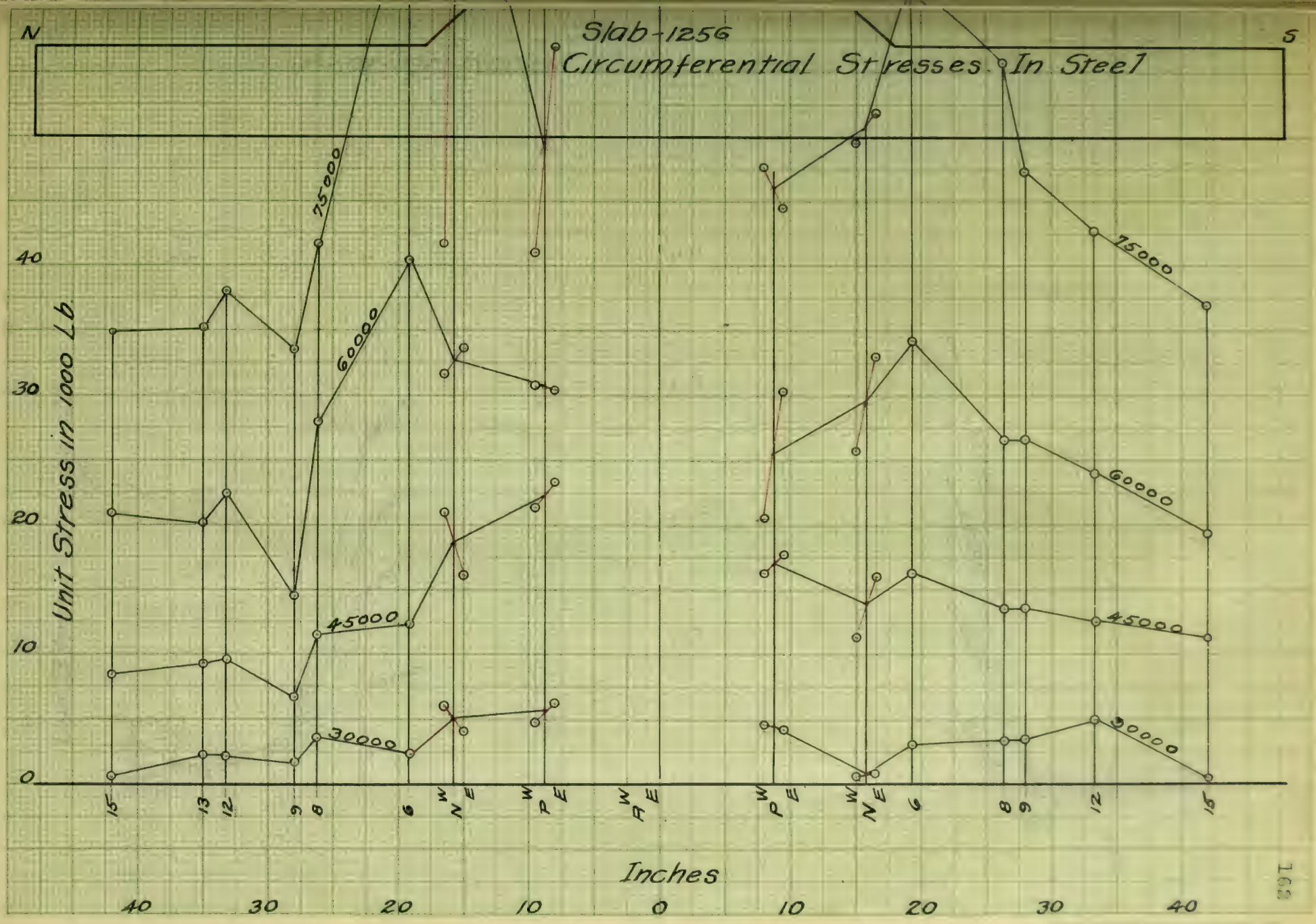

N
S
Slab-1256
Radial Stresses In Steel
Unit Stress in 1000 Lb.
40
30
20
10
0
75000
60000
45000
30000
D
C
B
A
A
B
C
Inches
40
30
20
10
0
10
20
30
40

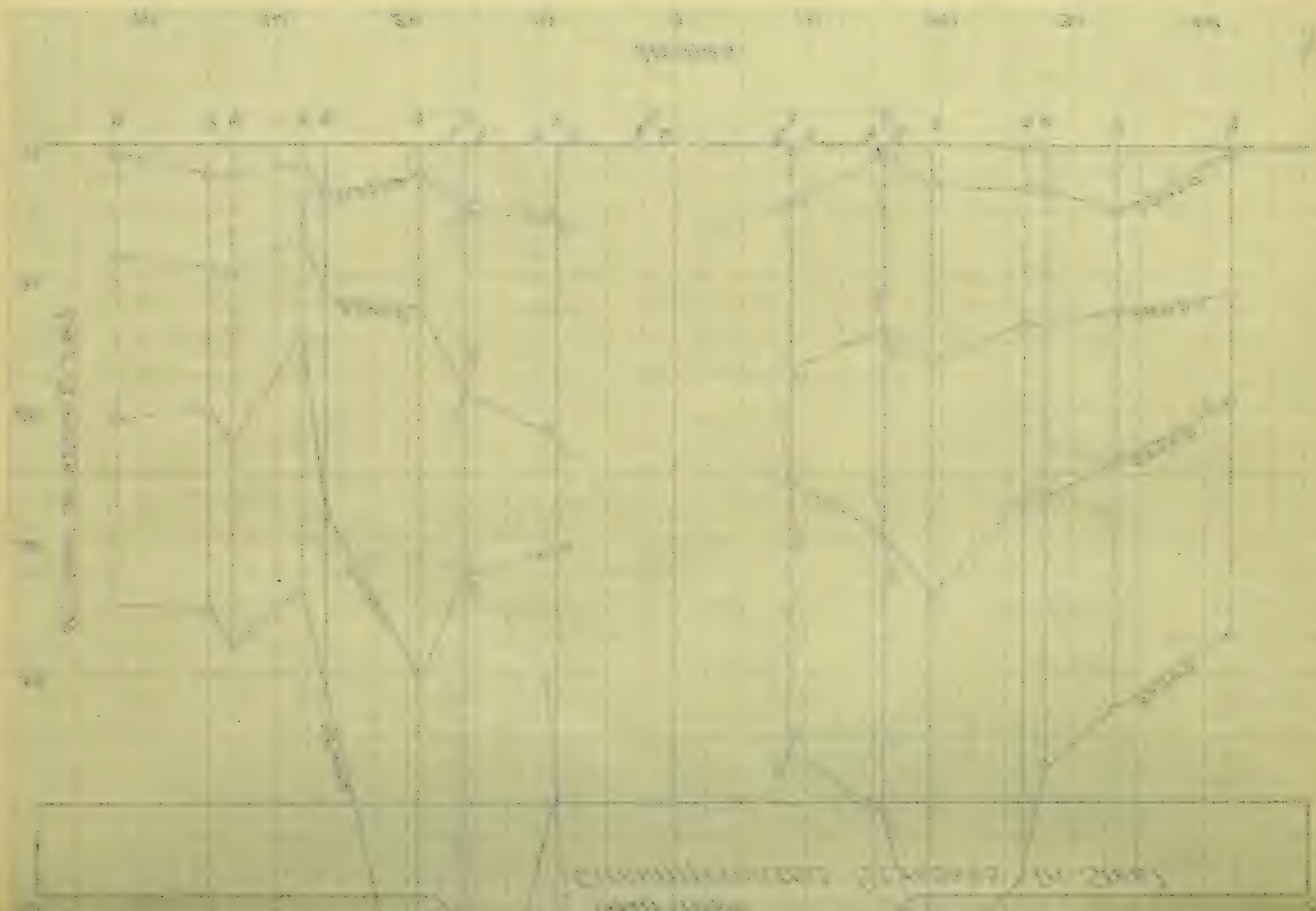



S-W
Slab - 1256
N-E
Average Circumferential Deformation In Steel
75000
60000
45000
30000
Unit Stress in 1000 Lb.
40
30
20
10
0
Inches
40
30
20
10
0
10
20
30
40


W
Slab-1256
E
Circumferential Stresses In Steel
Unit Stress in 1000 Lb
40
30
20
10
0
75000
60000
45000
30000
14
13
12
11
10
9
8
7
6
5
4
3
2
1
6
8
9
12
Inches
40
30
20
10
0
10
20
30
40




Slab-1256
Circumferential Stresses In Steel
N
S
Unit Stress in 1000 Lb.
75000
60000
45000
30000
40
30
20
10
0
15
13
12
9
8
6
W
N
E
W
P
E
W
A
E
W
P
E
W
N
E
6
8
9
12
15
Inches
40
30
20
10
0
10
20
30
40

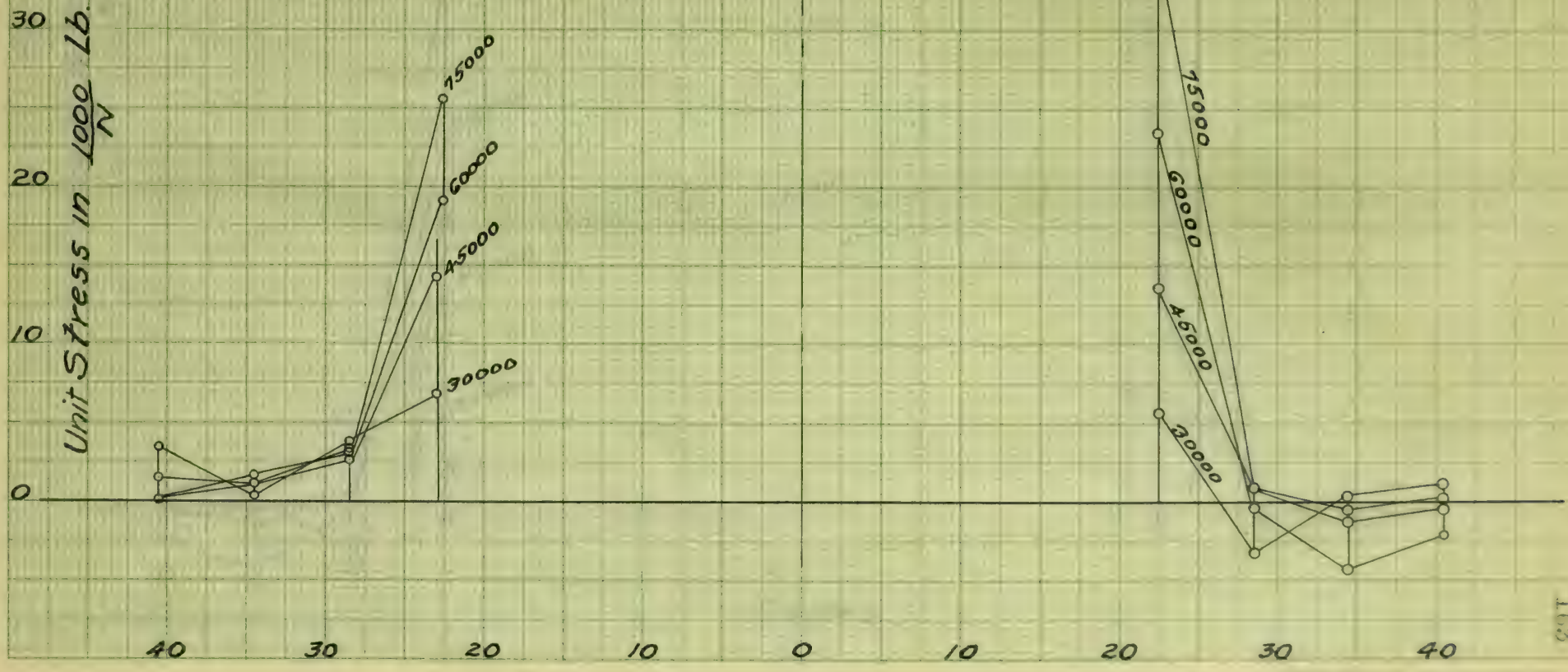


S-W

Slab -1256

N-E

Average Radial Deformation In Concrete



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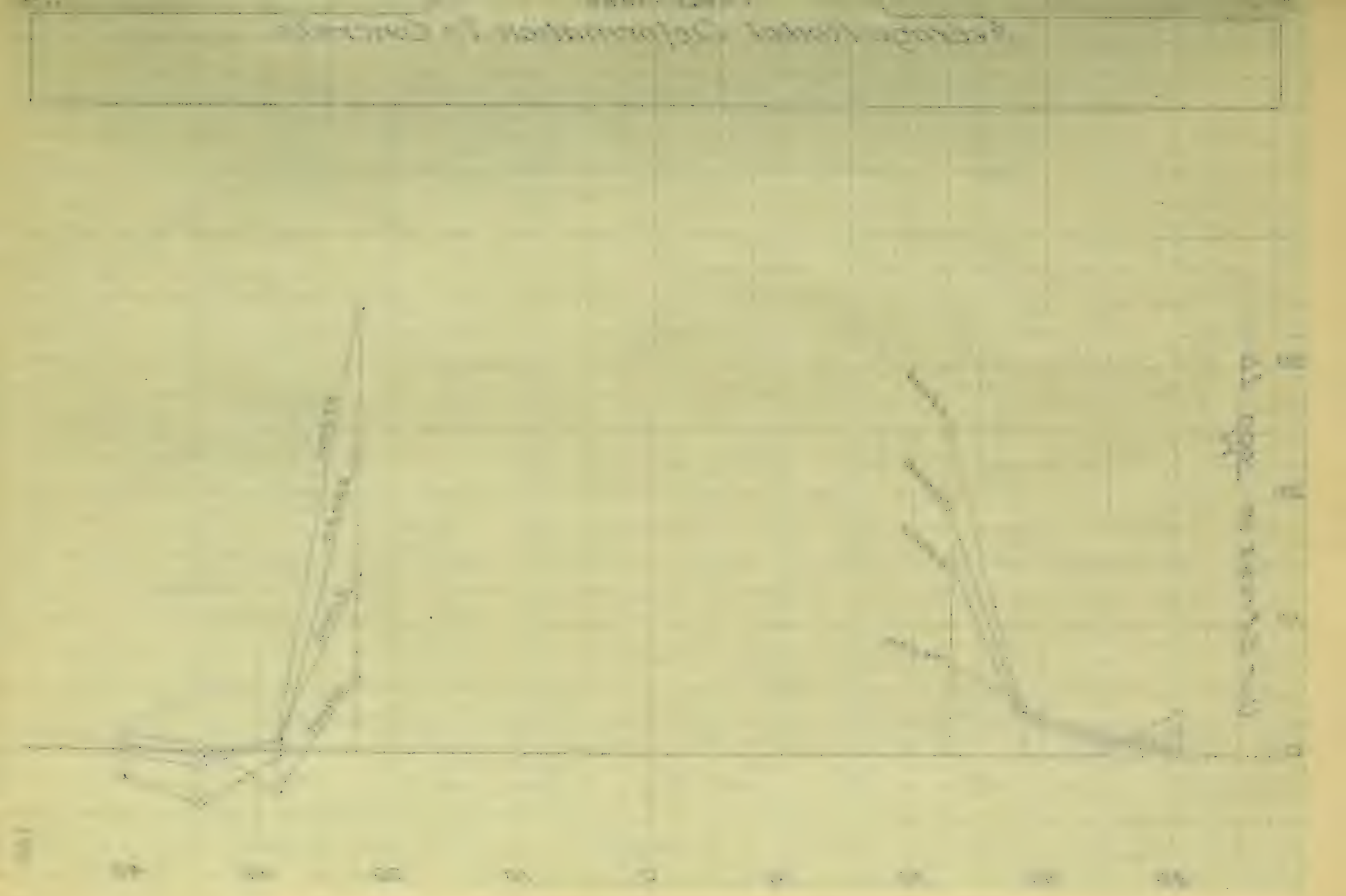
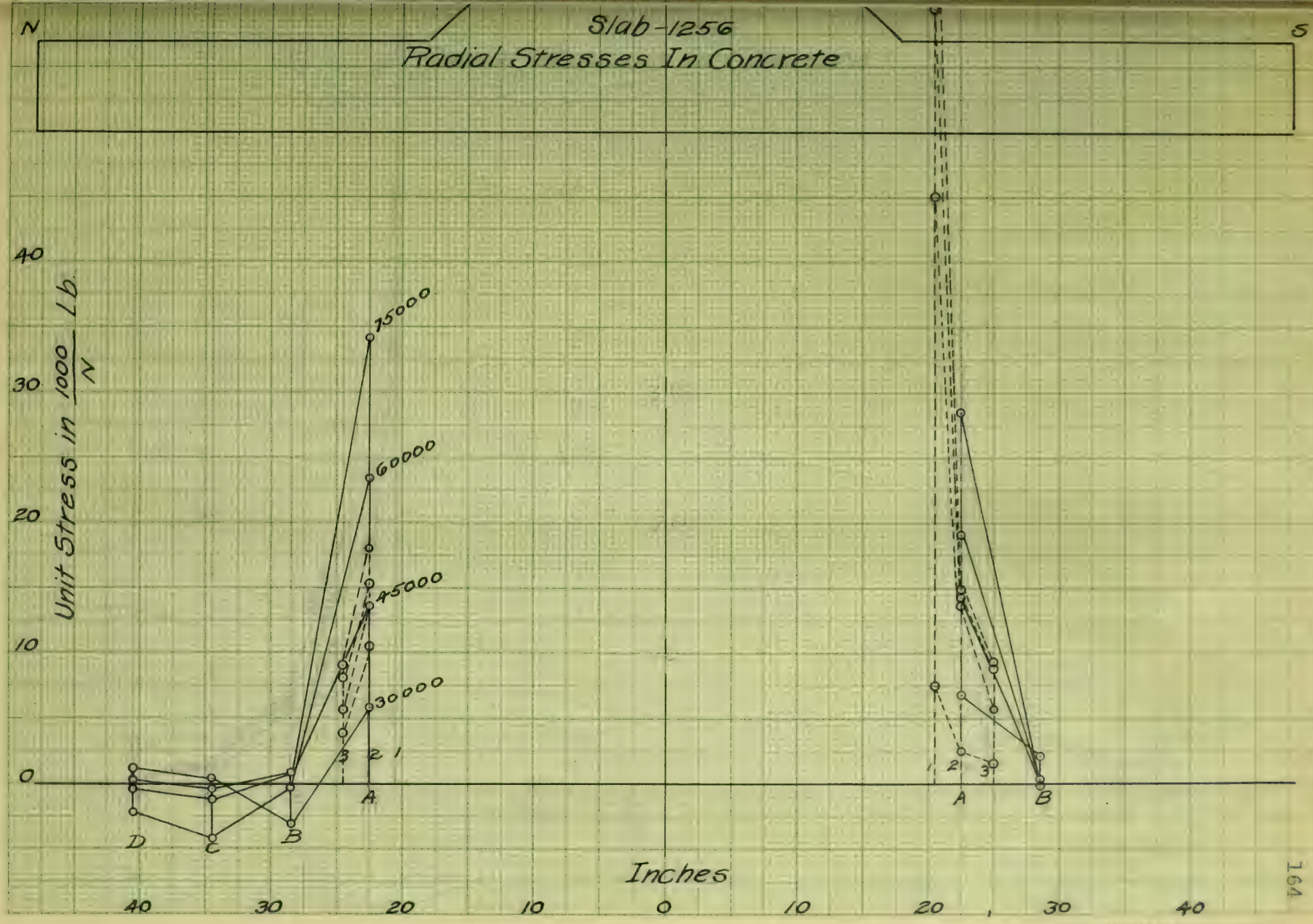
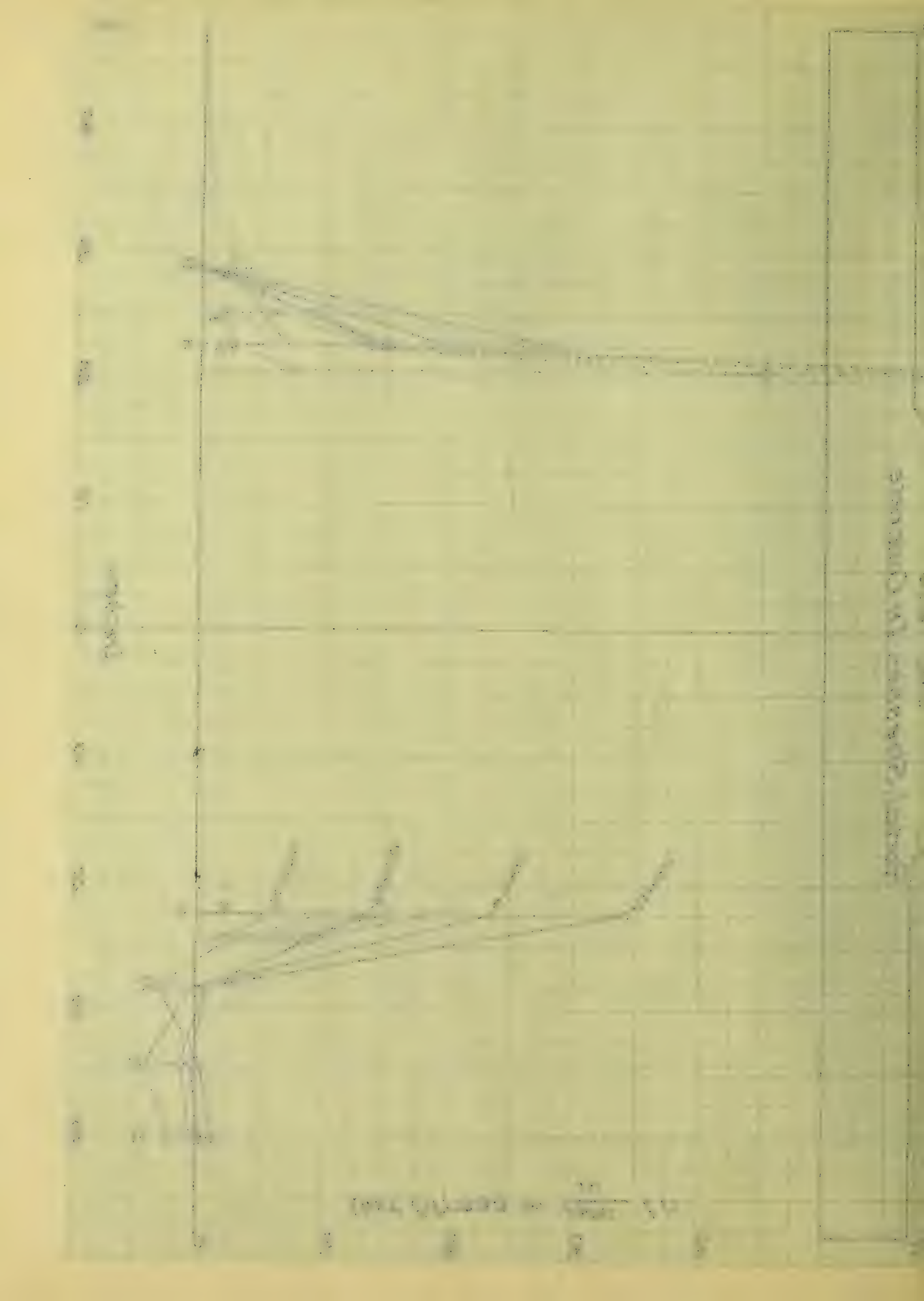
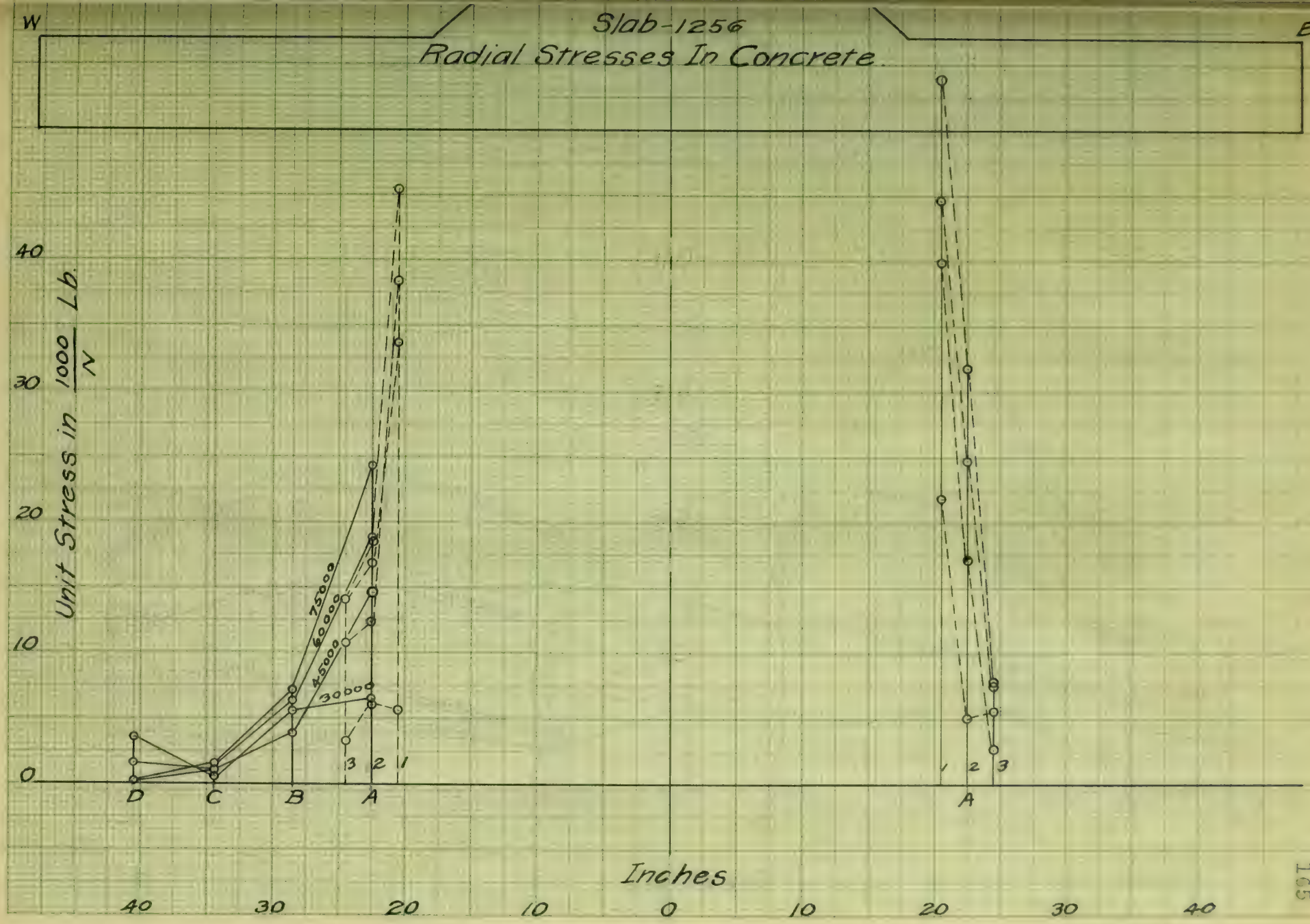
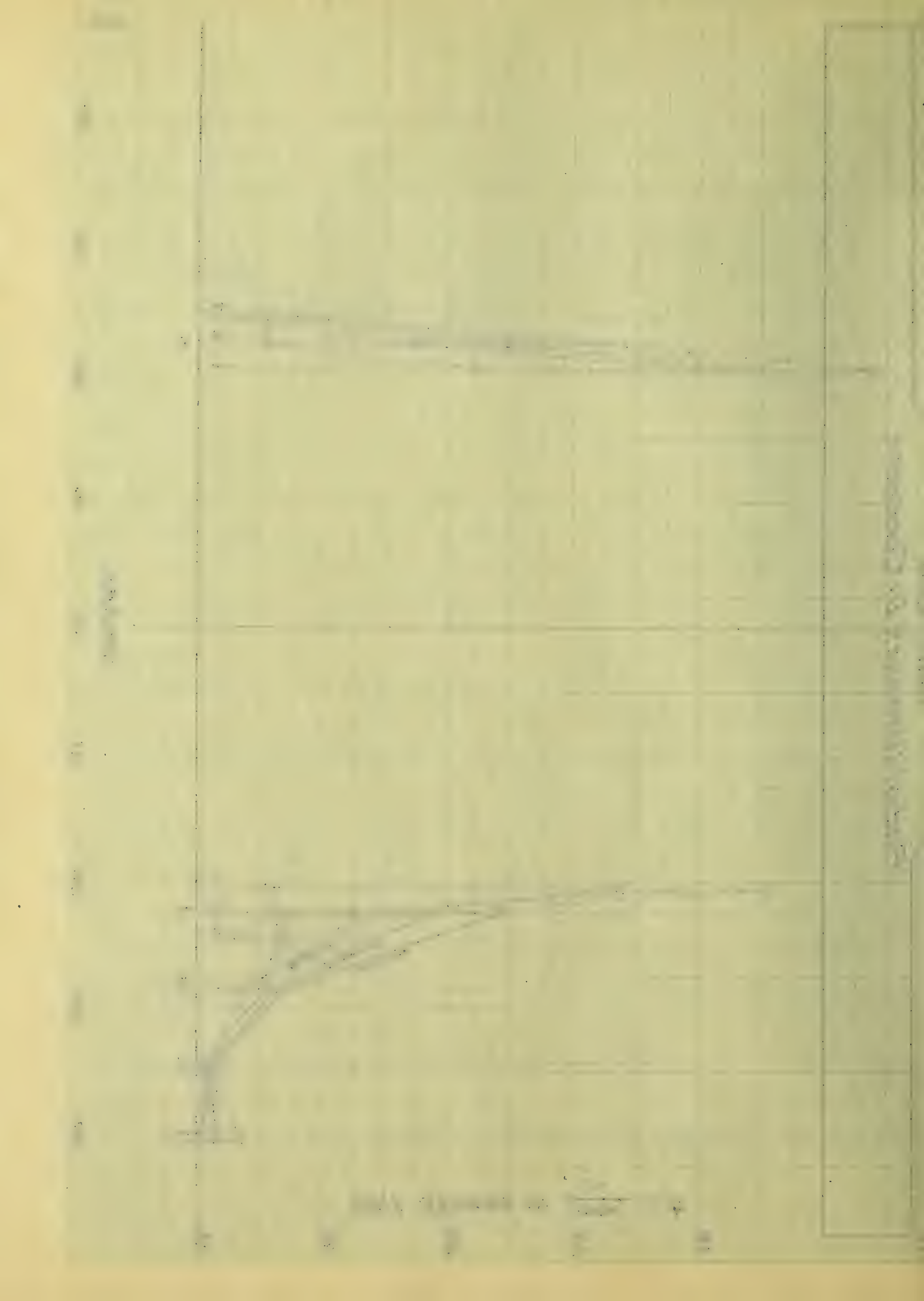



N
S
Slab-1256
Radial Stresses In Concrete
Unit Stress in 1000 Lb. N
40
30
20
10
0
75000
60000
45000
30000
3
2
1
A
D
C
B
2
3
A
B
Inches
40
30
20
10
0
10
20
30
40




W
Slab-1256
E
Radial Stresses In Concrete
Unit Stress in 1000 Lb. N
40
30
20
10
0
75000
60000
45000
30000
3
2
1
D
C
B
A
1
2
3
A
Inches
40
30
20
10
0
10
20
30
40

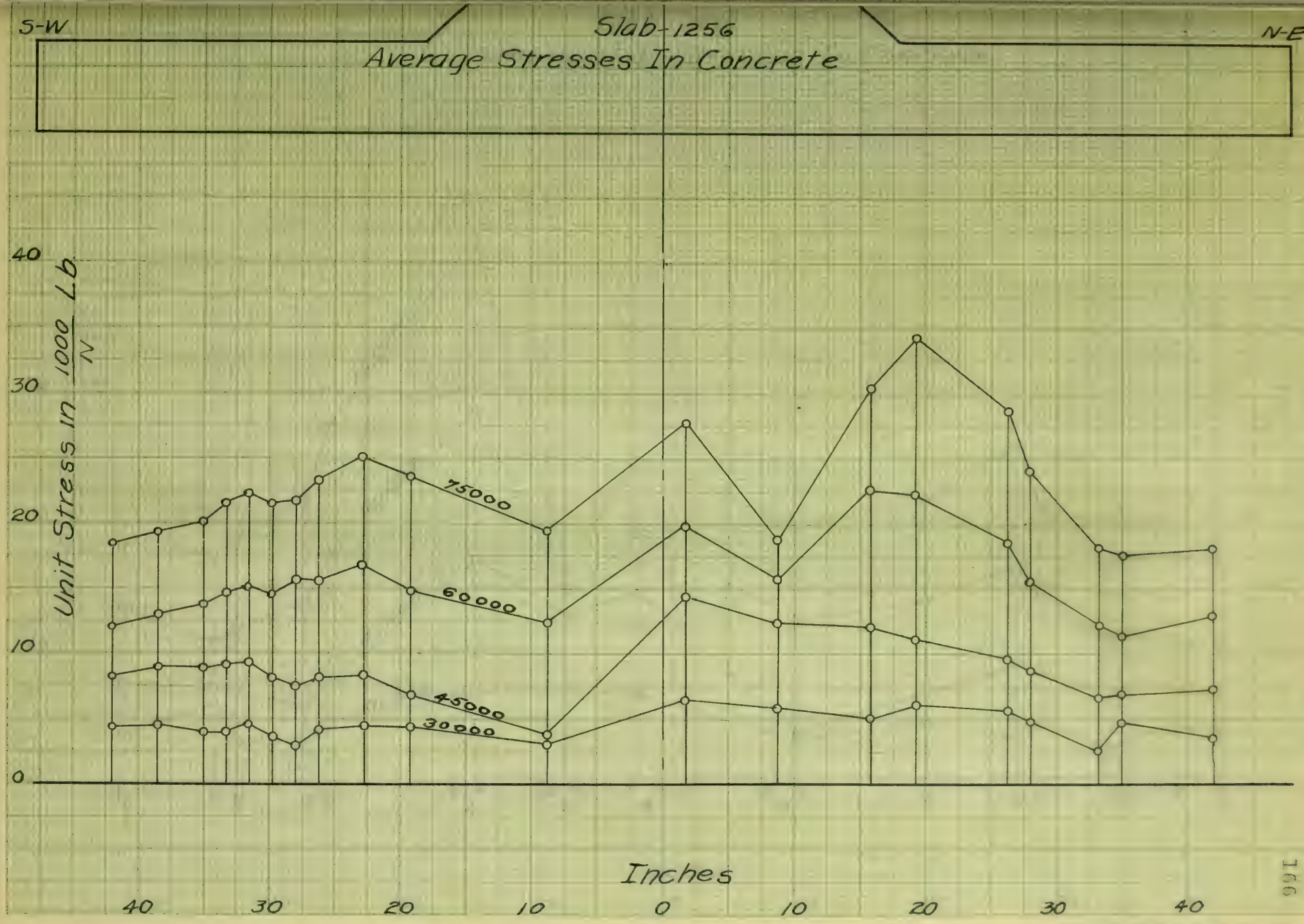


S-W

Slab-1256

N-E

Average Stresses In Concrete



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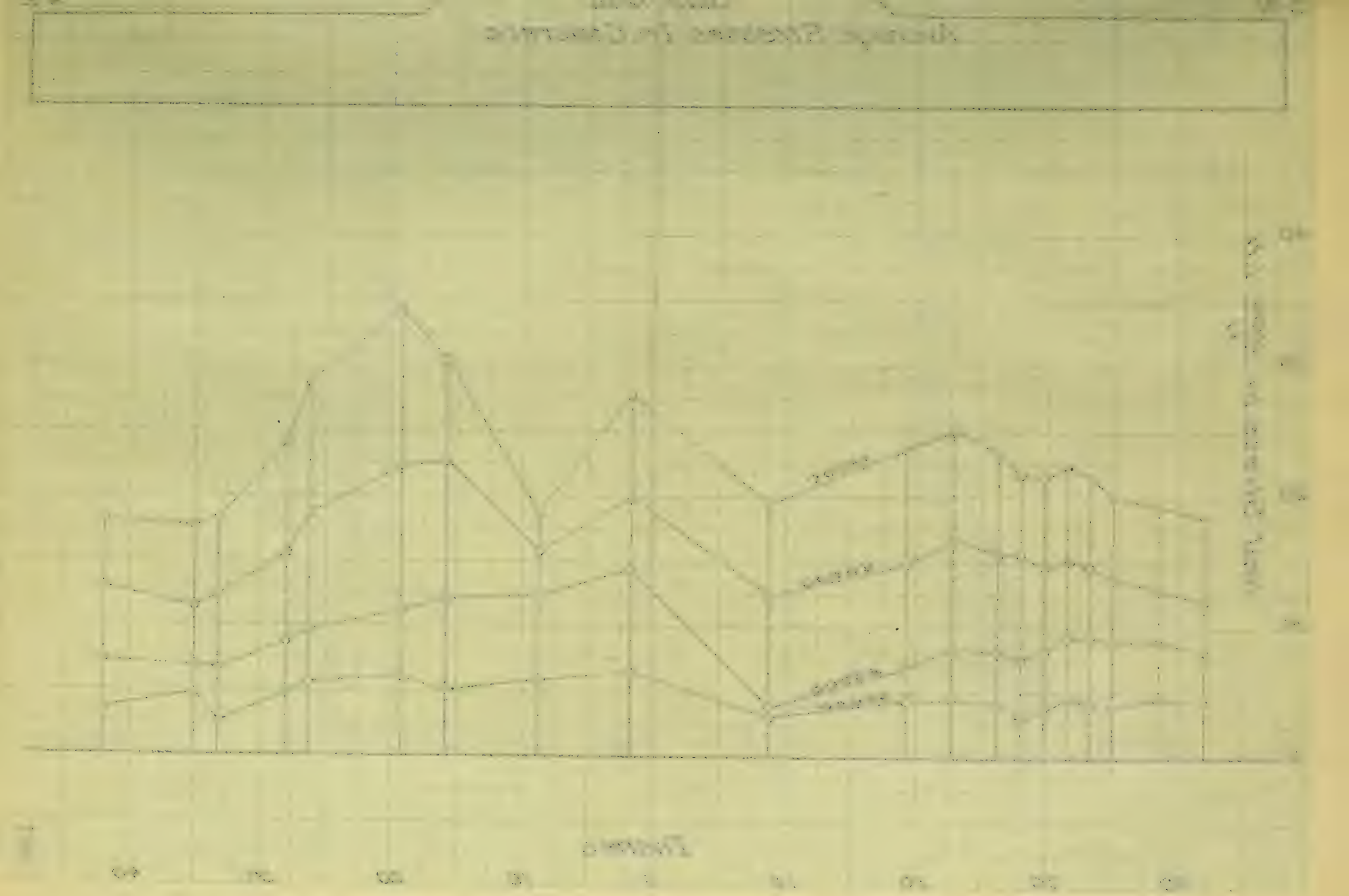
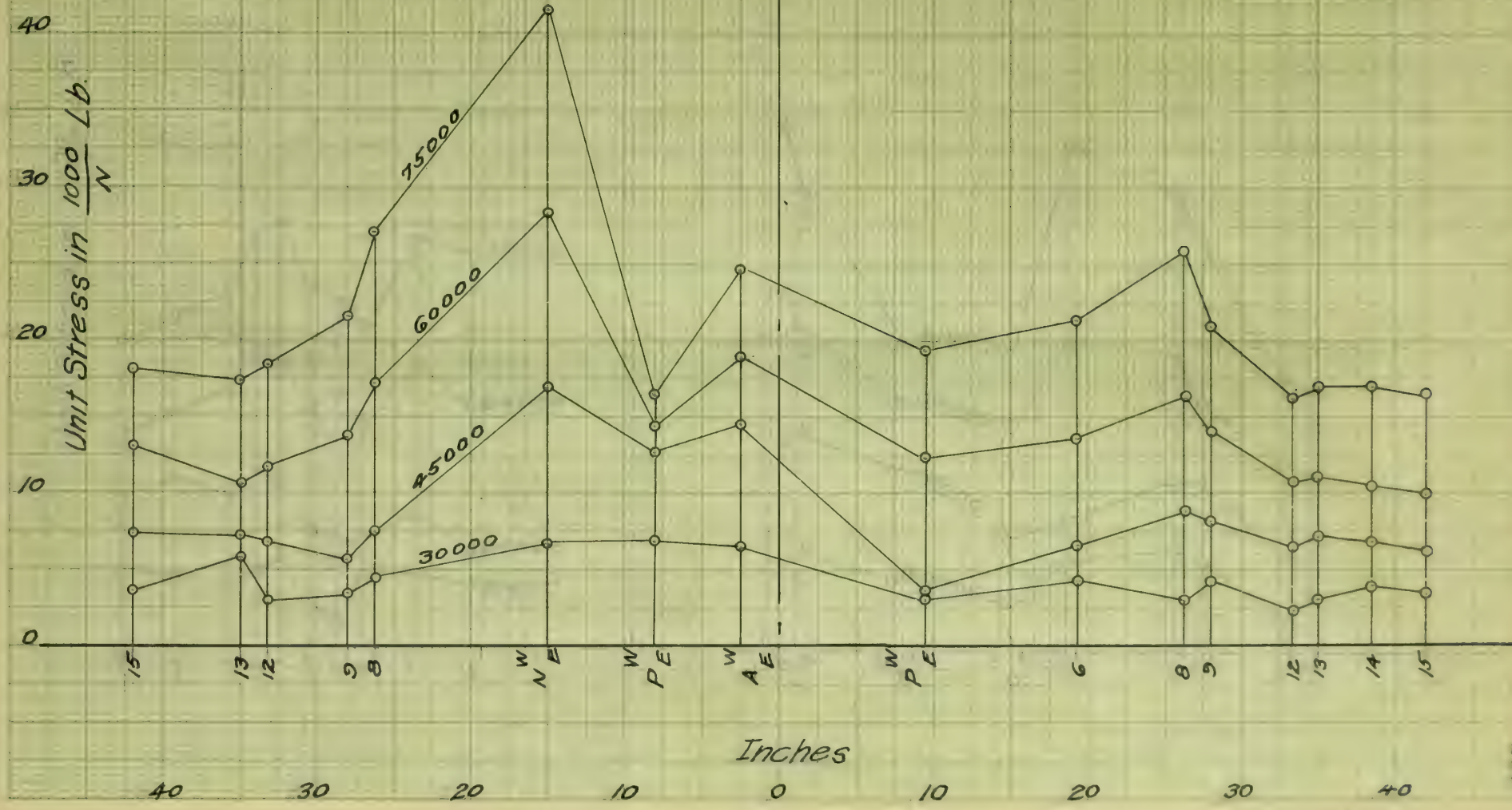


N

Slab-1256

5

Circumferential Stresses In Concrete



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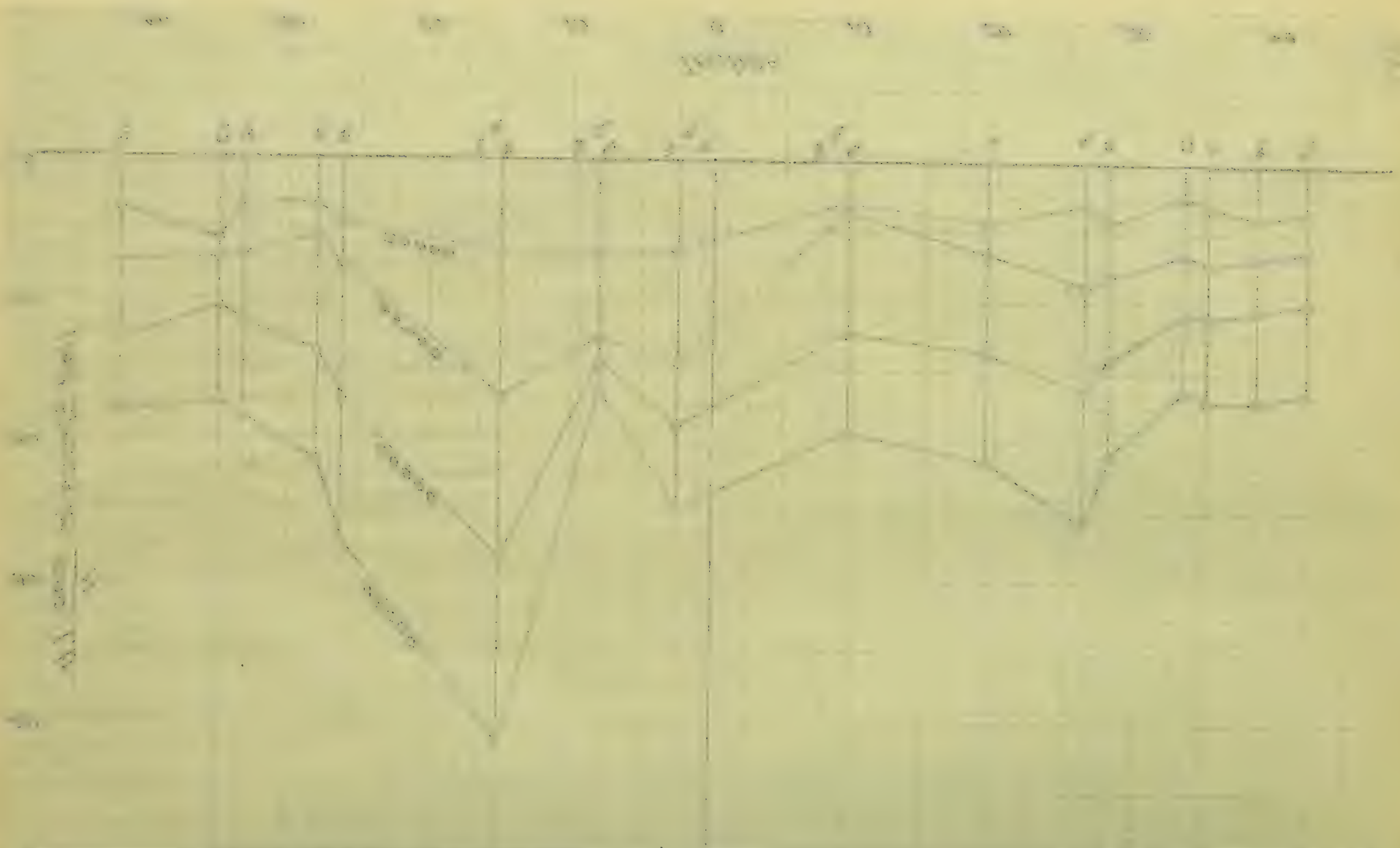
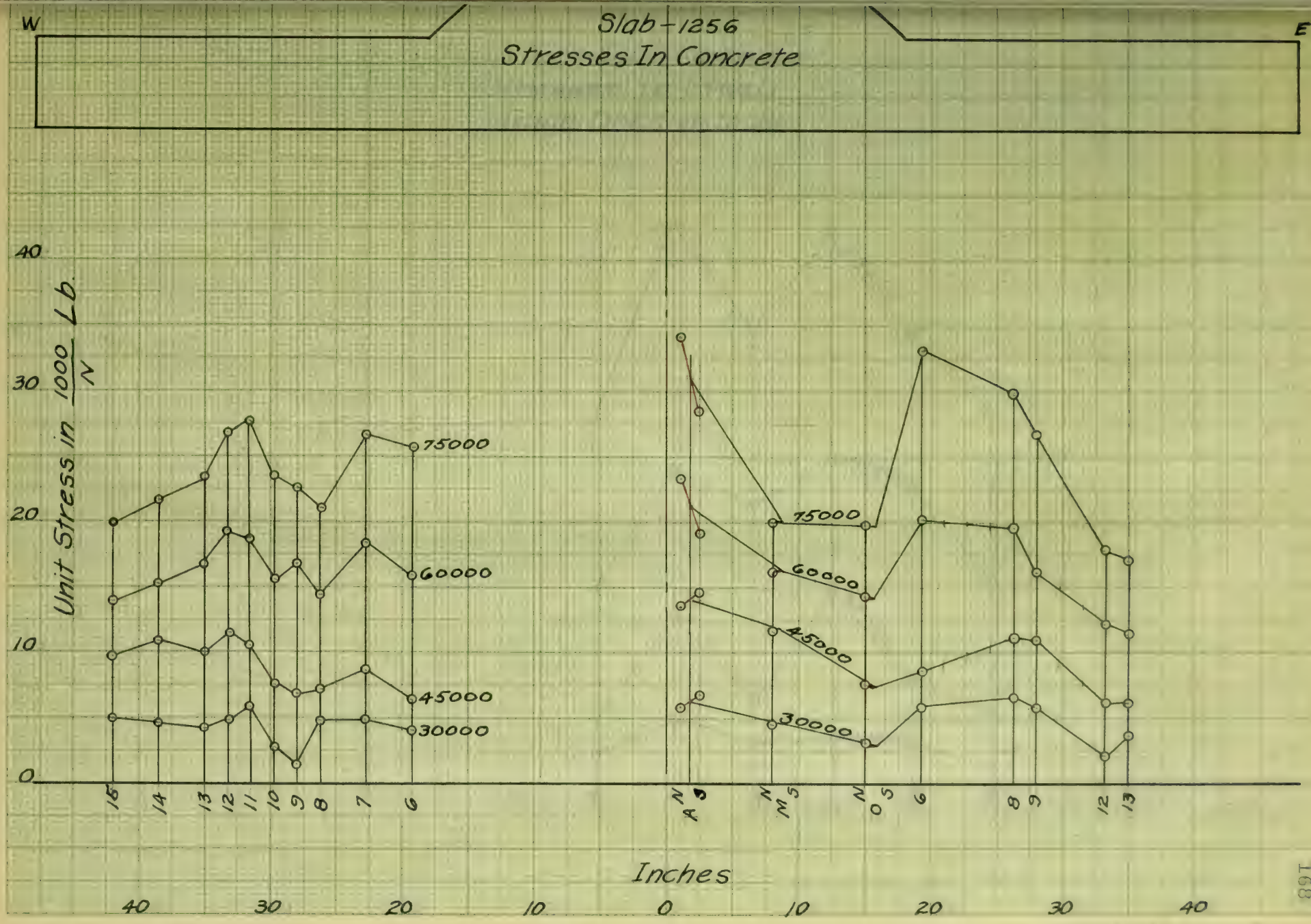
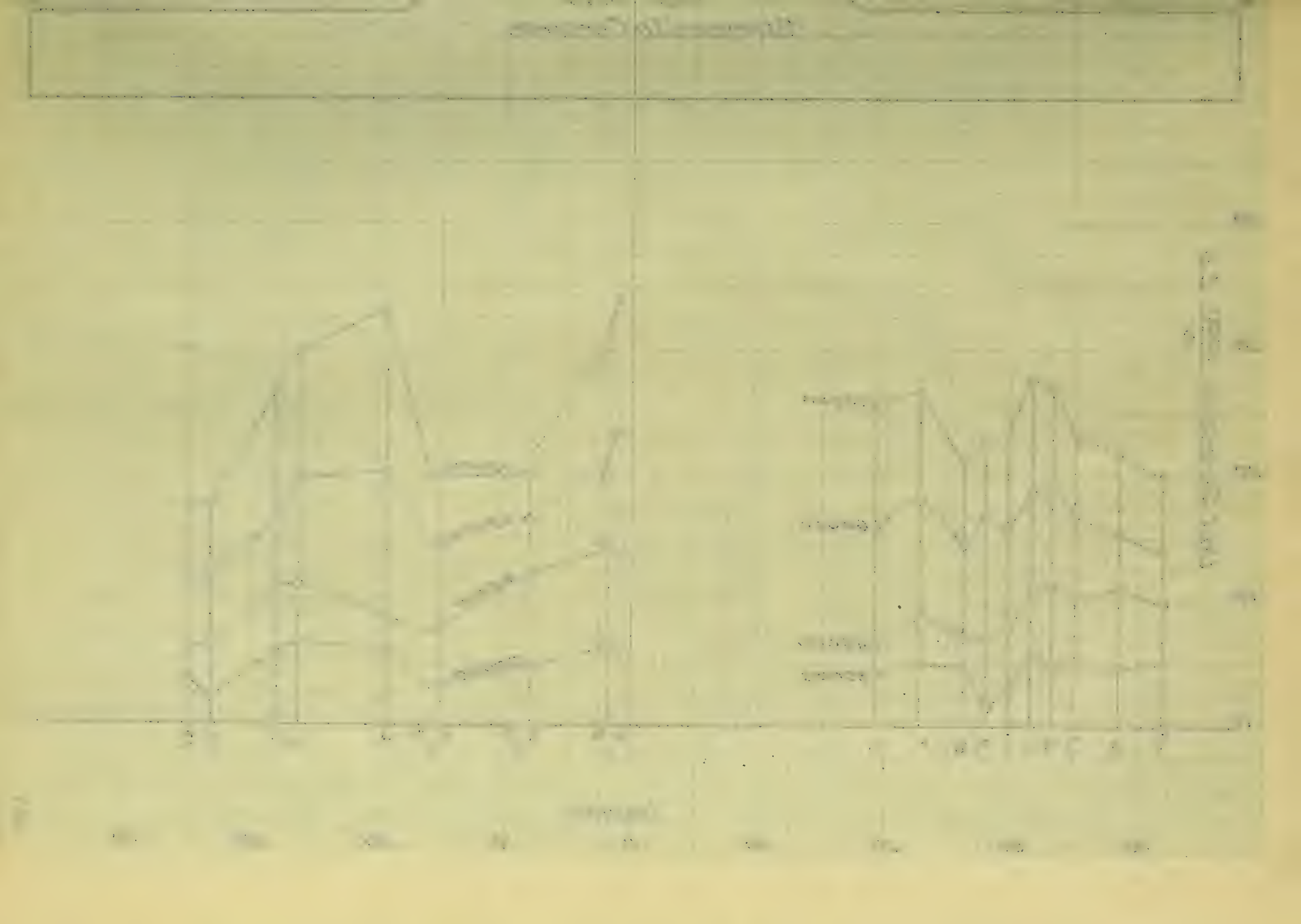
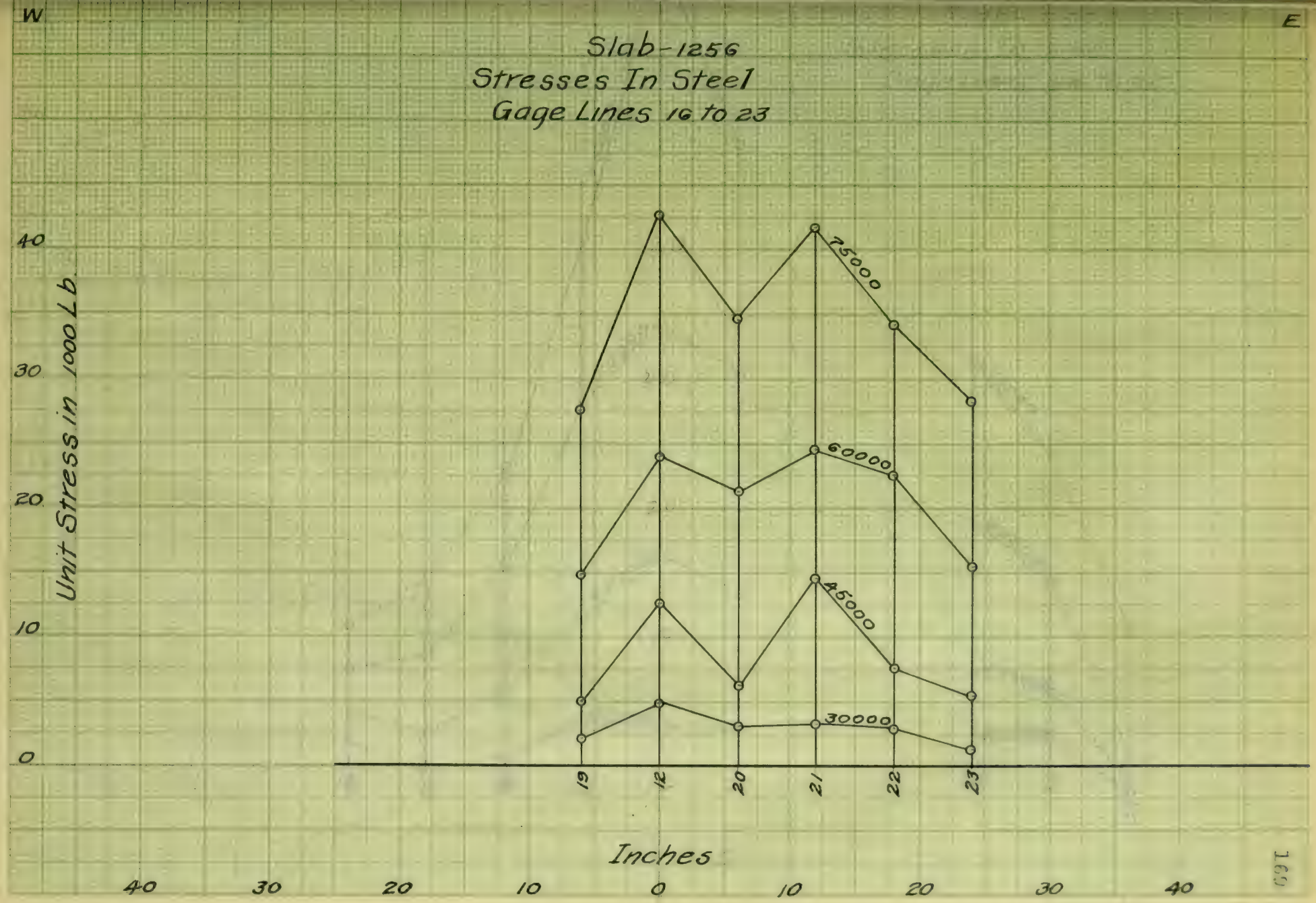
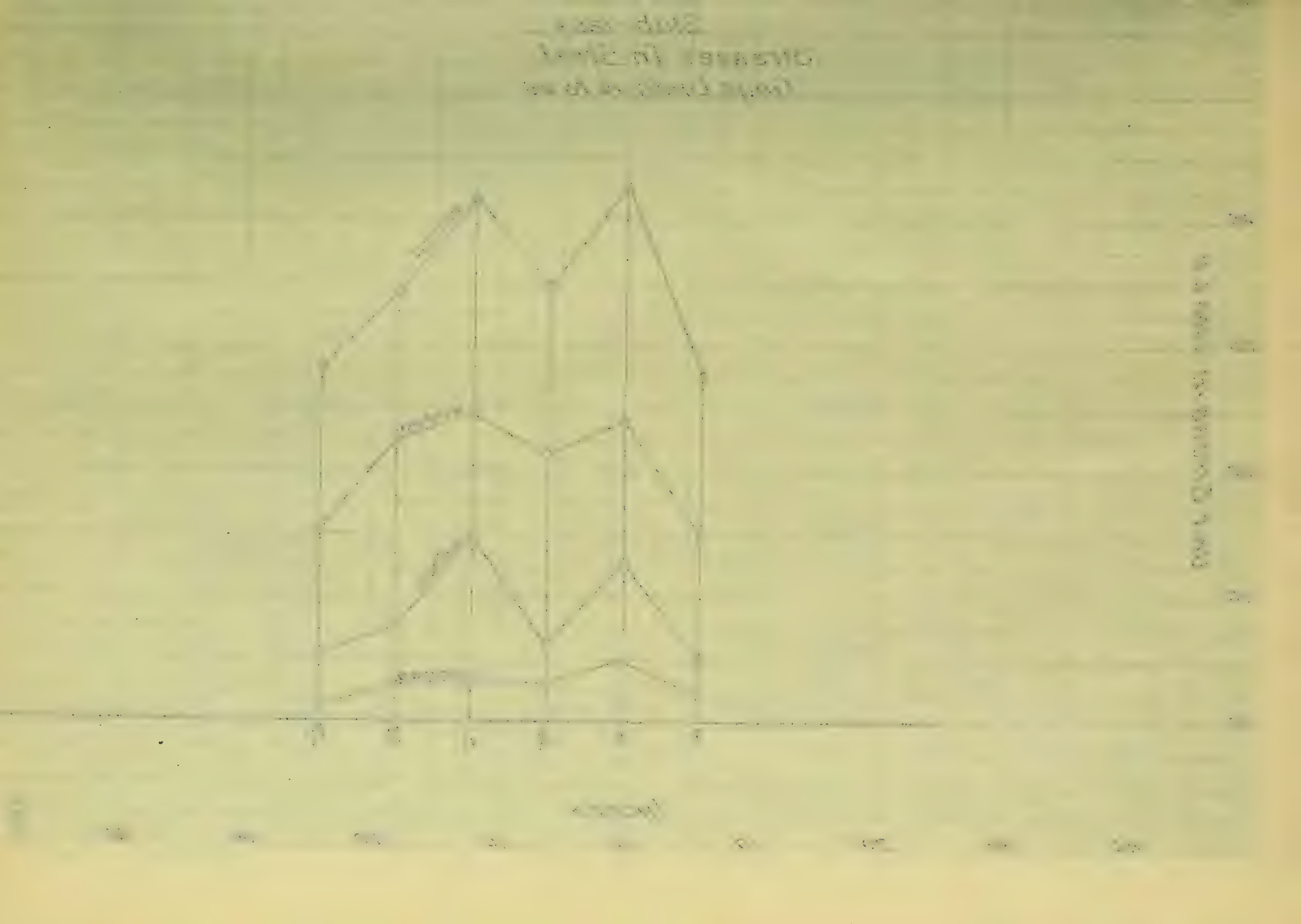
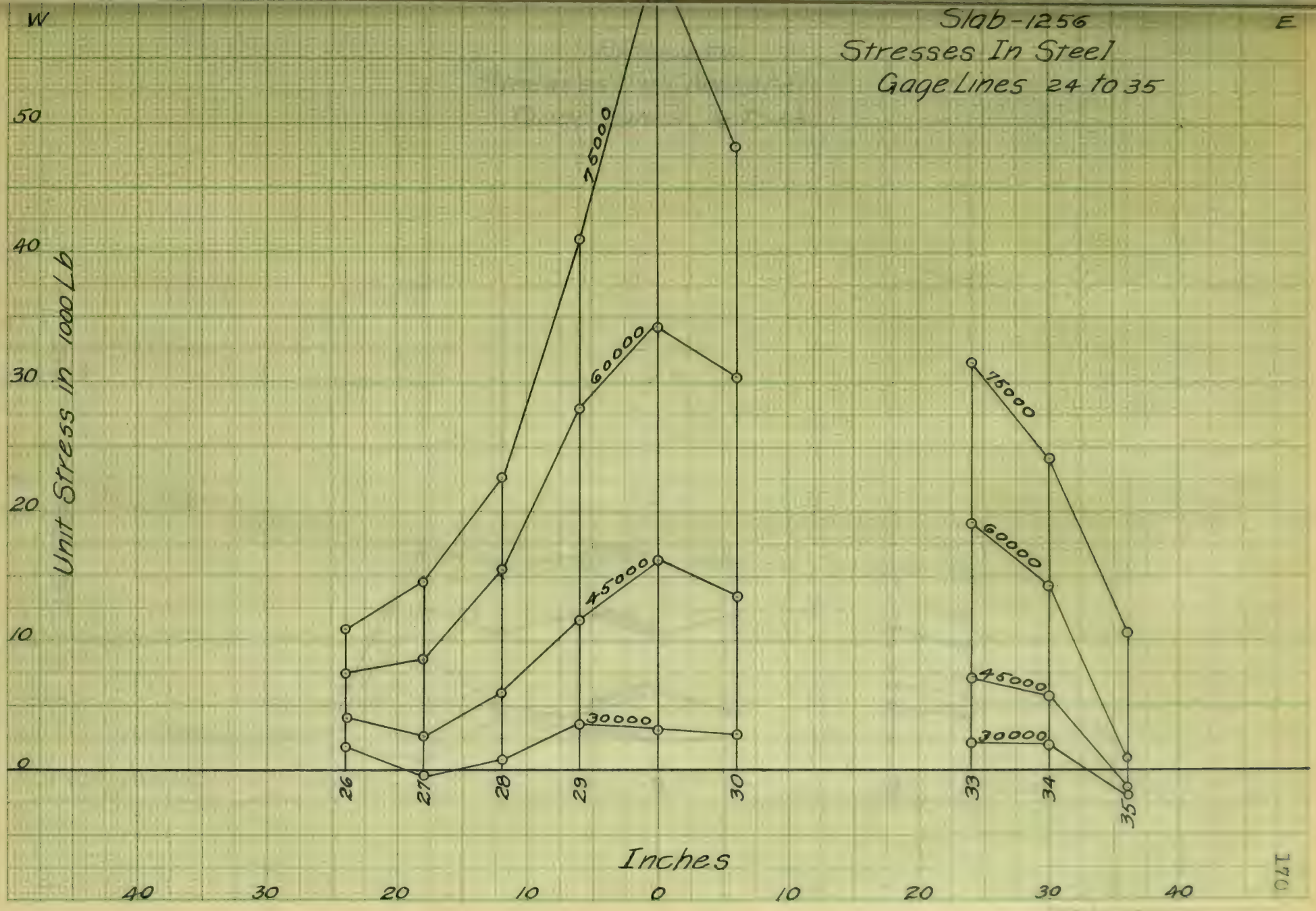


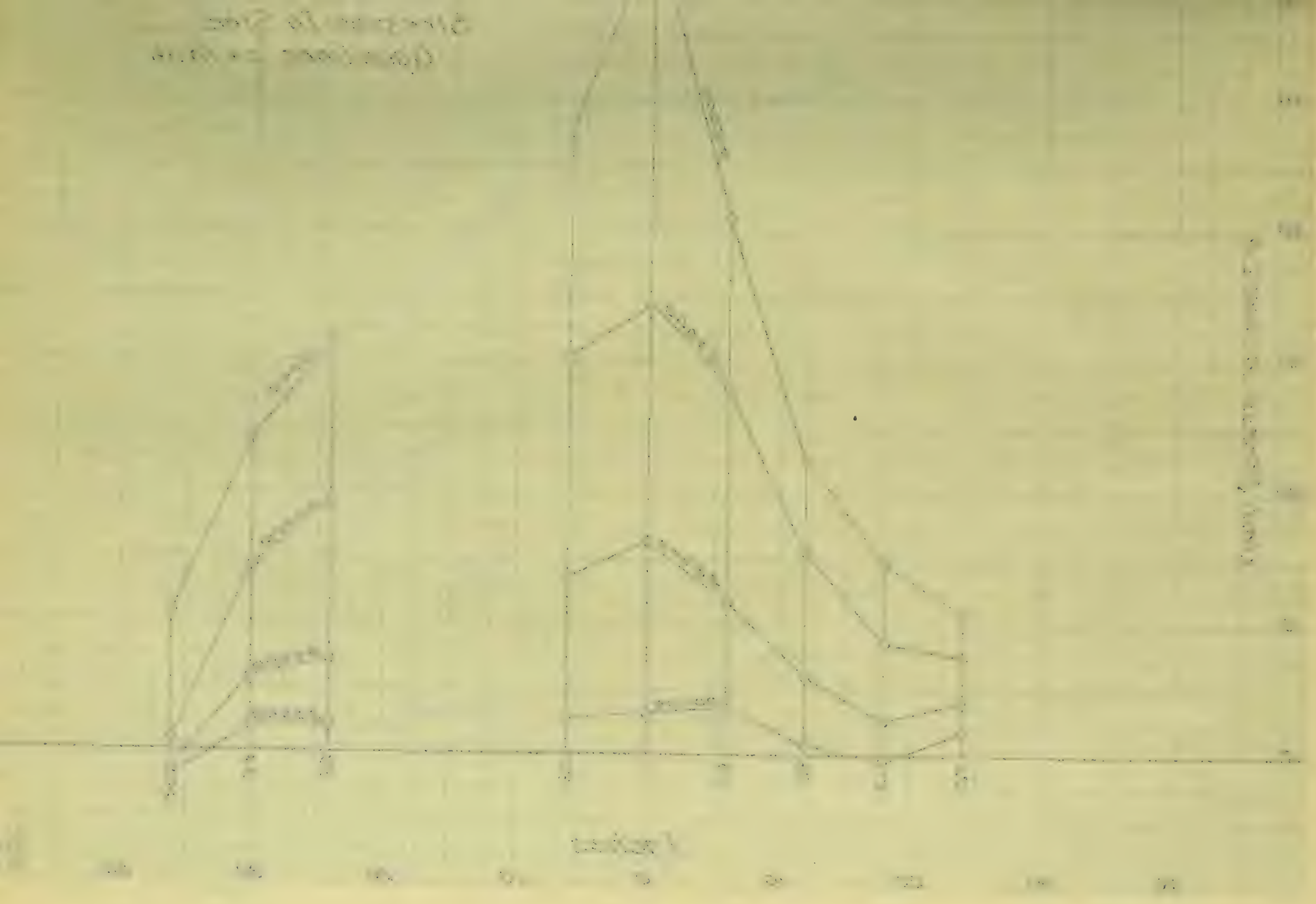

W
E
Slab-1256
Stresses In Concrete
Unit Stress in 1000 Lb. / N
40
30
20
10
0
75000
60000
45000
30000
15 14 13 12 11 10 9 8 7 6
N 4 5
N 3 5
N 0 5
6 8 9 12 13
Inches
40 30 20 10 0 10 20 30 40




W
E
Slab-1256
Stresses In Steel
Gage Lines 16 to 23
Unit Stress in 1000 Lb
40
30
20
10
0
75000
60000
45000
30000
19
12
20
21
22
23
Inches
40
30
20
10
0
10
20
30
40

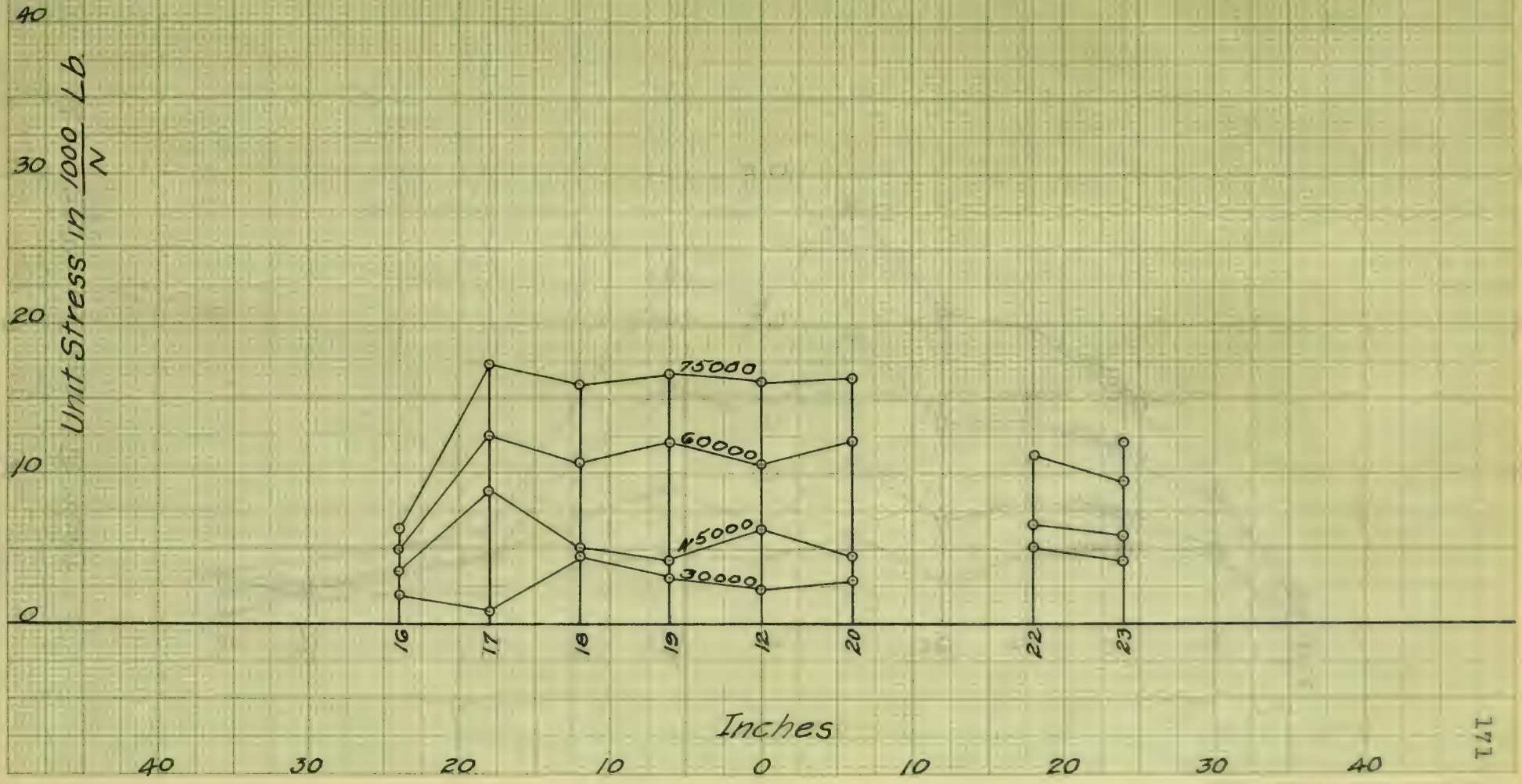


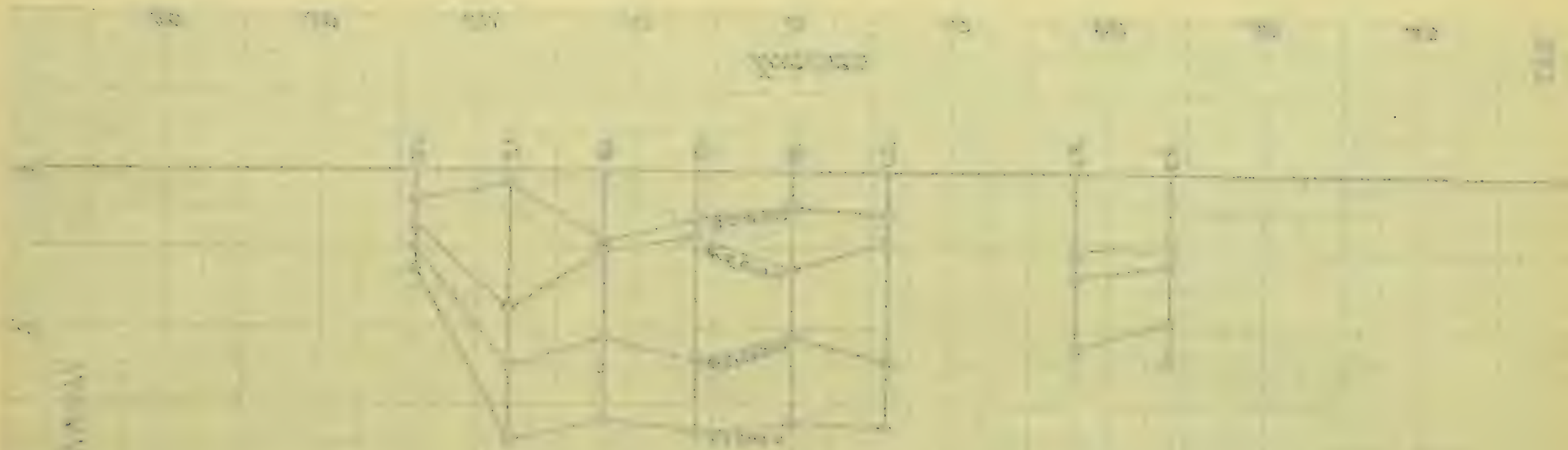

W
E
Slab-1256
Stresses In Steel
Gage Lines 24 to 35
Unit Stress in 1000 Lb
50
40
30
20
10
0
75000
60000
45000
30000
26
27
28
29
30
33
34
35
Inches
40
30
20
10
0
10
20
30
40

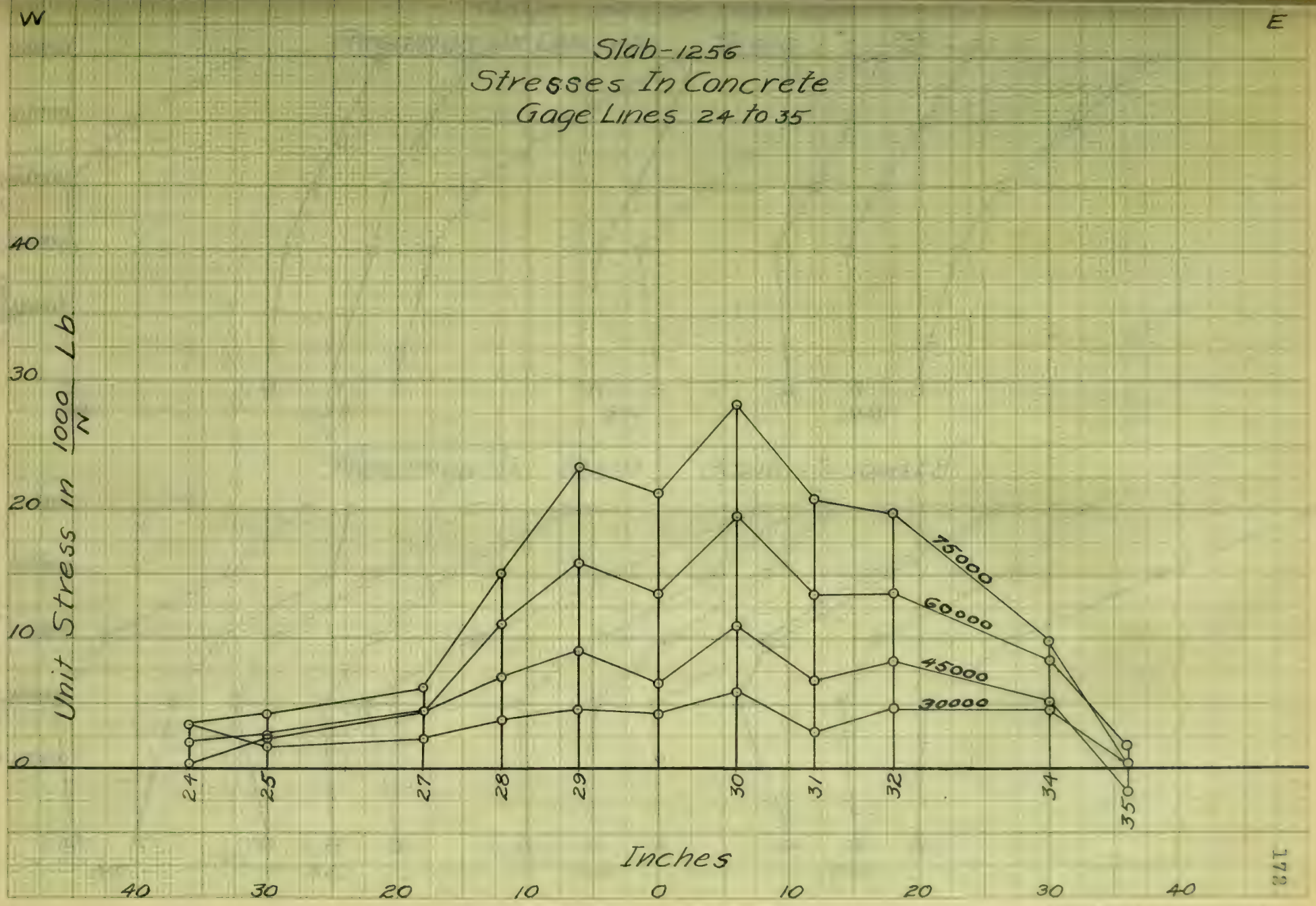


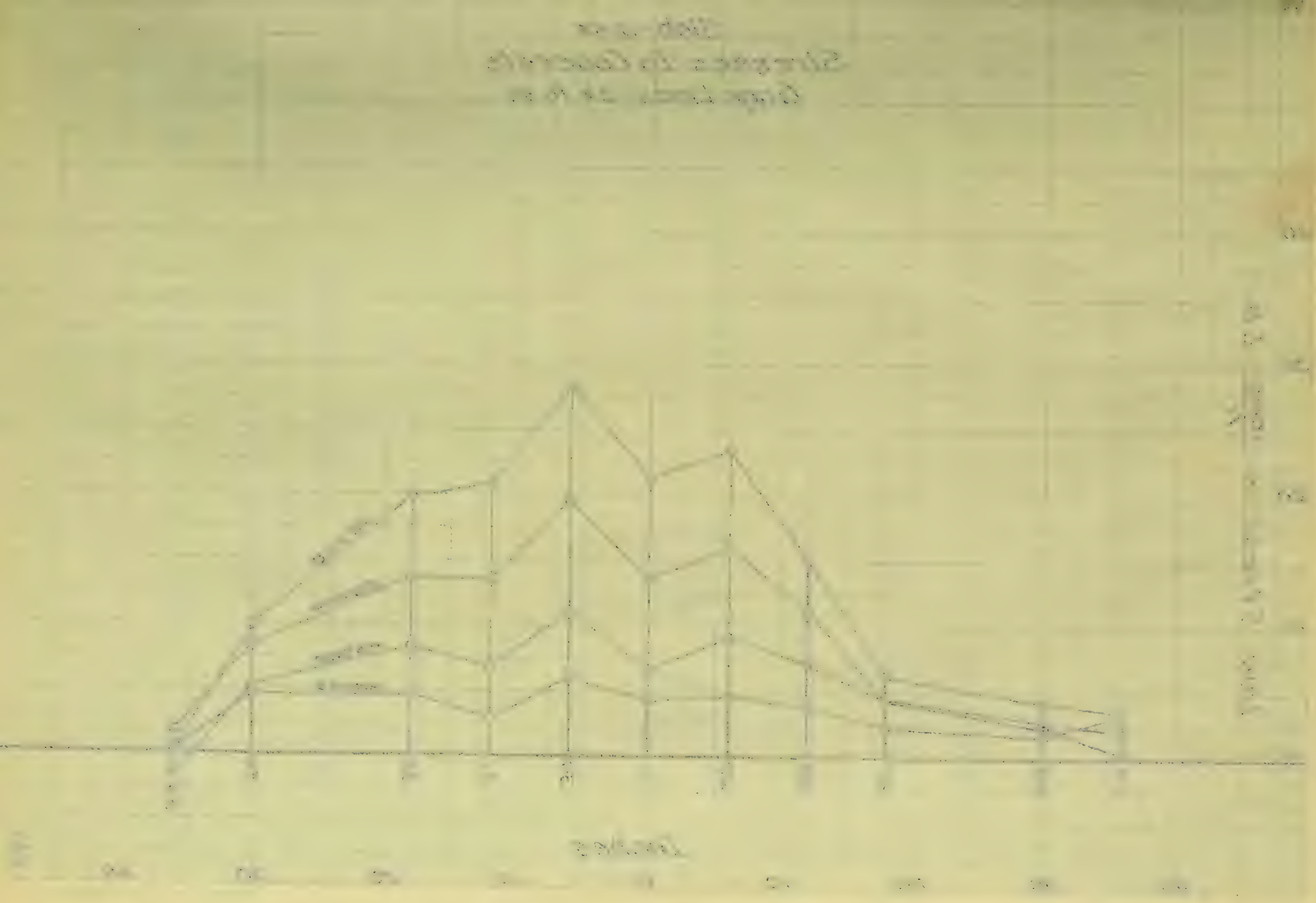
W E

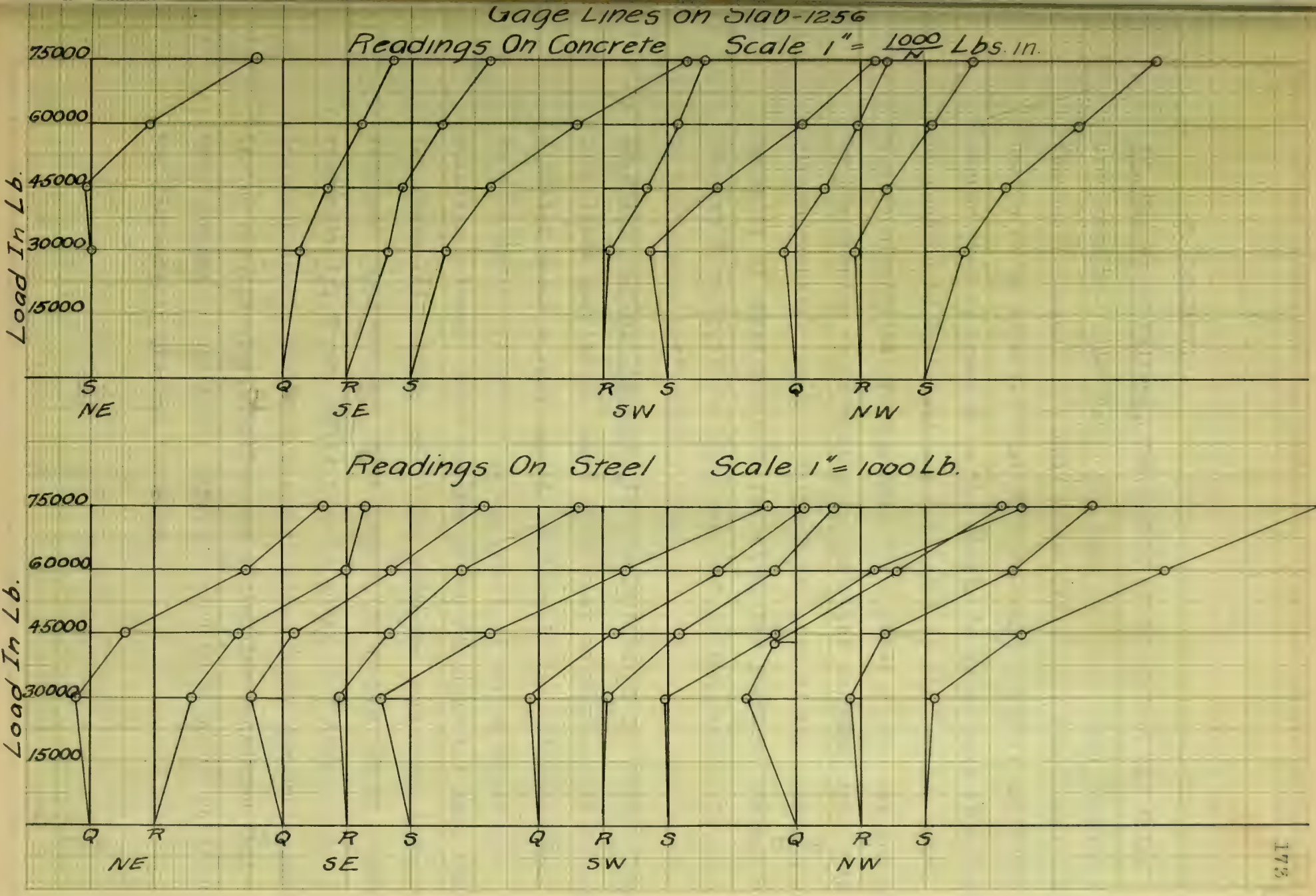
Slab-1256
Stresses In Concrete
Gage Lines 16 to 23

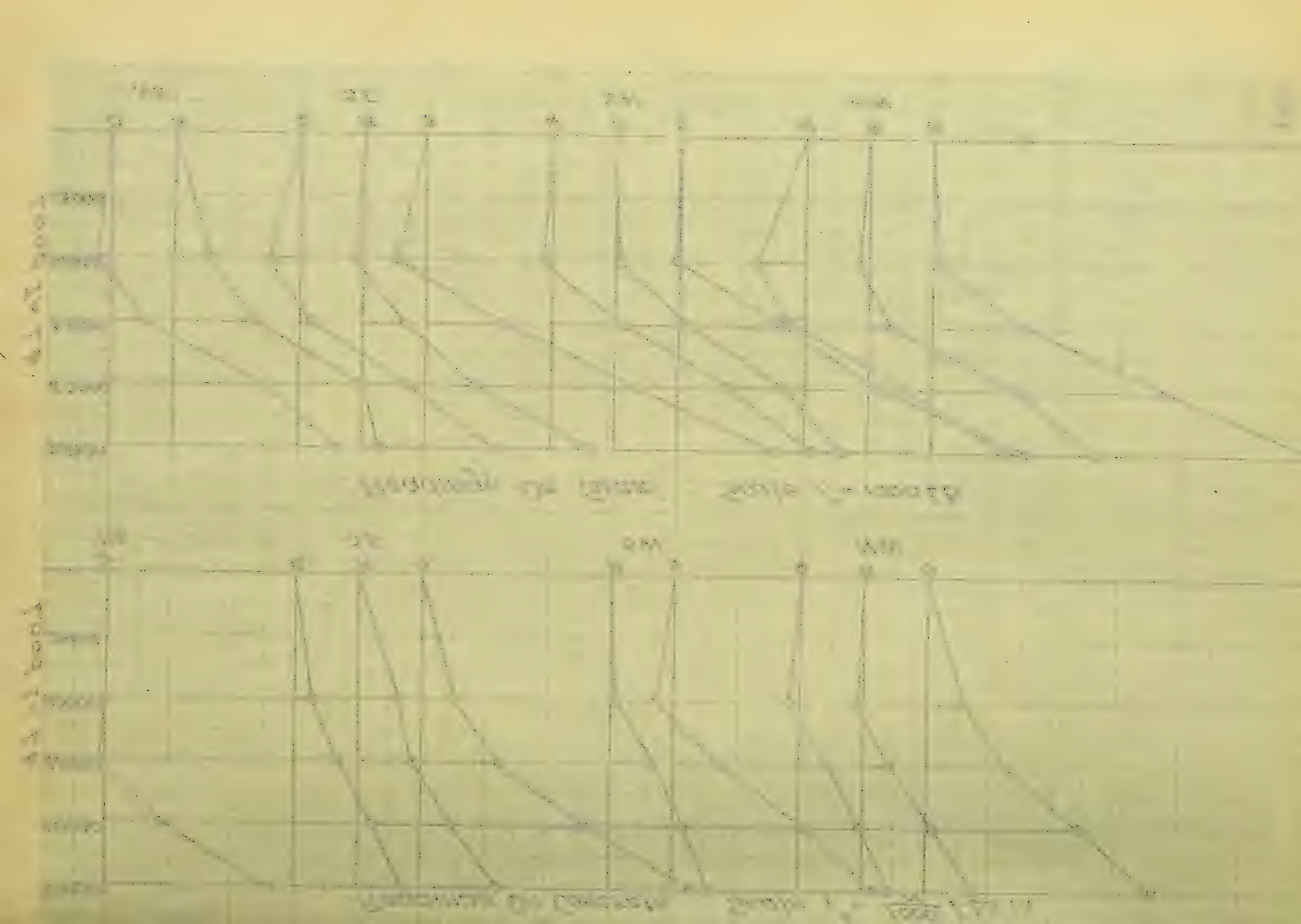





W
E
Slab-1256
Stresses In Concrete
Gage Lines 24 to 35
Unit Stress in 1000/N Lb.
40
30
20
10
0
15000
60000
45000
30000
24
25
27
28
29
30
31
32
34
35
Inches
40
30
20
10
0
10
20
30
40
178




Gage Lines on Slab-1256
Readings On Concrete Scale 1" = 1000/N Lbs. in.
Load In Lb.
75000
60000
45000
30000
15000
S
NE
Q
R
S
SE
R
S
SW
Q
R
S
NW
Readings On Steel Scale 1" = 1000 Lb.
Load In Lb.
75000
60000
45000
30000
15000
Q
R
NE
Q
R
S
SE
Q
R
S
SW
Q
R
S
NW



F. SUMMARY.

24. Manner of Failure. The manner of failure of all these specimens was practically the same in every case. Because of the small percent of steel(about .6% in all specimens), it was hardly to be expected that failure could occur in any other manner than by tension in the steel. In every case this failure by tension in the steel was indicated by the opening up of a circumferential crack around the outside of the cap and also by the opening up of radial cracks which extended from this circumferential crack to the outside edge of the slab. In the majority of cases the slab failed by the punching through of the cap finally,if the load was kept on long enough to open up the cracks sufficiently wide.

25.Effect of Cap diameter. An examination of the table of maximum loads carried by slabs shows that an increase in the cap diameter means a very marked increase in the ultimate load. An examination of the following sheet of curves shows the relation between the stresses in the steel at the same loads for slabs 1251, 1252, and 1254, with the same steel reinforcing and cap diameters of 24 inches, 36 inches and 48 inches respectively. These curves make it clear that there is a decrease in the steel stresses at given loads for an increase in the cap diameter. Furthermore it is also indicated that the decrease in the steel stress occurs at a faster rate than the increase in the cap diameter.

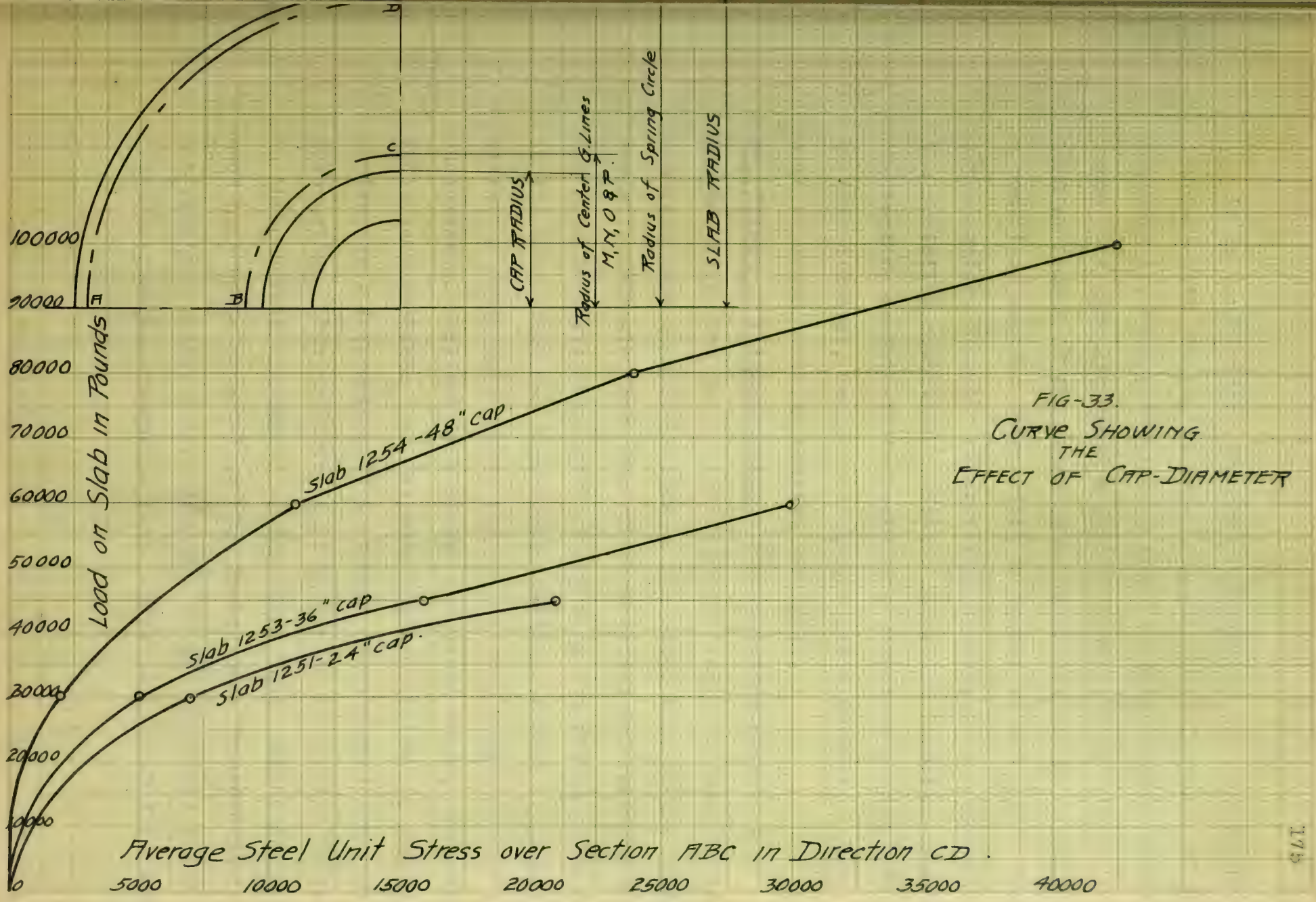
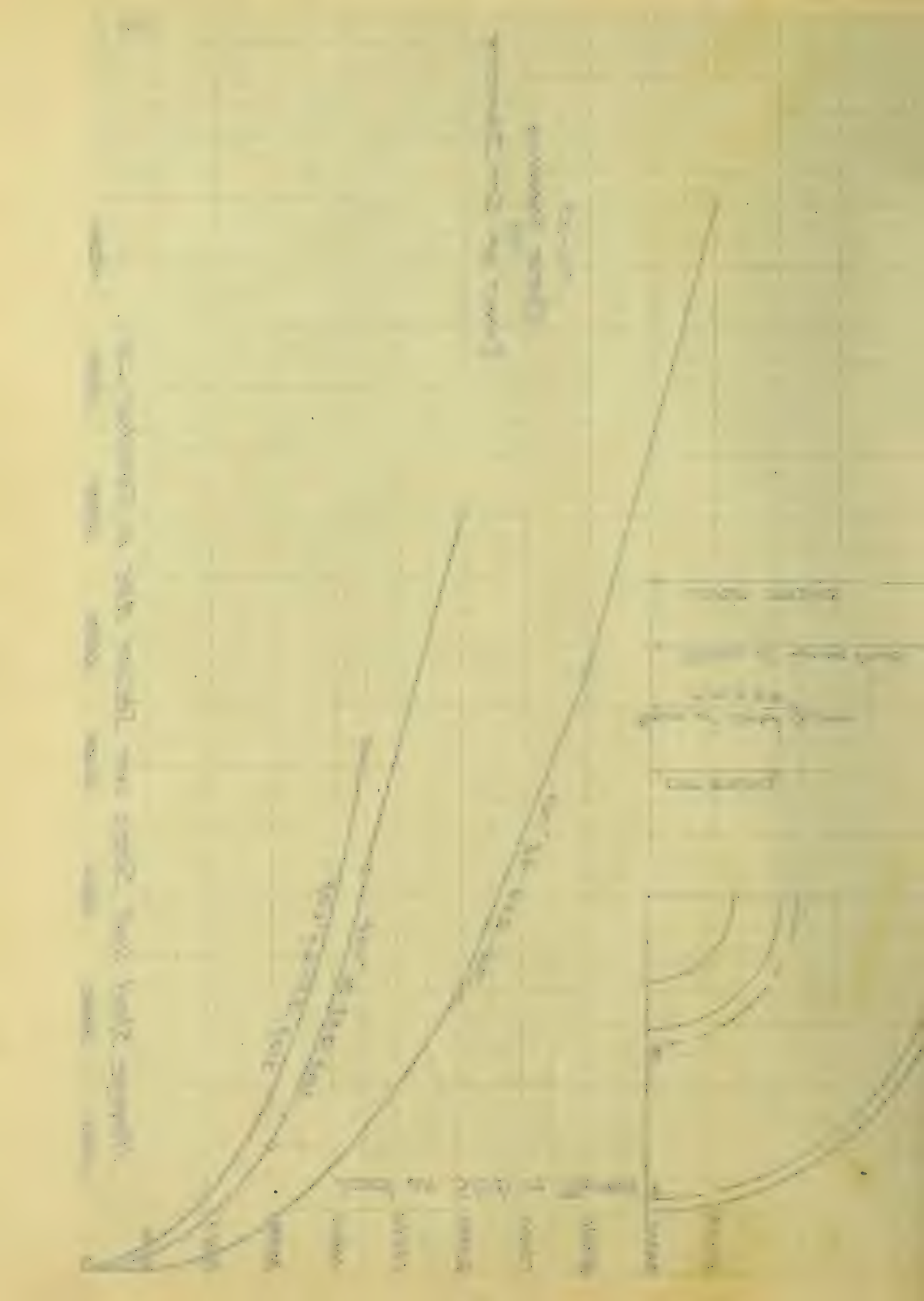


FIG-33.
CURVE SHOWING
THE
EFFECT OF CAP-DIAMETER



It is very evident that the strength of the slab should increase with the cap diameter and there are two ways of explaining it. From one point of view, if we consider the resistance of a circular section just outside the cap to the bending moment of the loads in a radial direction, we have a resisting section whose width increases directly with the cap diameter. From the other point of view, if we consider the resisting moment of a section along the diameter against the bending moment of the loads in a direction perpendicular to this diameter, we have for larger cap diameters, a beam with a larger concrete section available.

26. Effect of Poissons Ratio. The fact that part of the curves which show the variation of the radial stress in the concrete have negative values on the outer half of the radius seems to indicate that the circumferential deformations in the concrete have the effect of reducing the radial deformations at the same point and vice versa. Radial stresses in the concrete along the outer half of the radius are very small and the circumferential stresses have almost a maximum value. Therefore it is very probable that Poissons Ratio mutiplied by the circumferential deformation will in many cases exceed the radial deformation, thus producing a small amount of tension radially in the concrete instead of compression. This phenomenon is much more to be expected at high loads where Poissons Ratio has greater values, and an examination of the curves shows that the general tendency of the curves is in that direction.

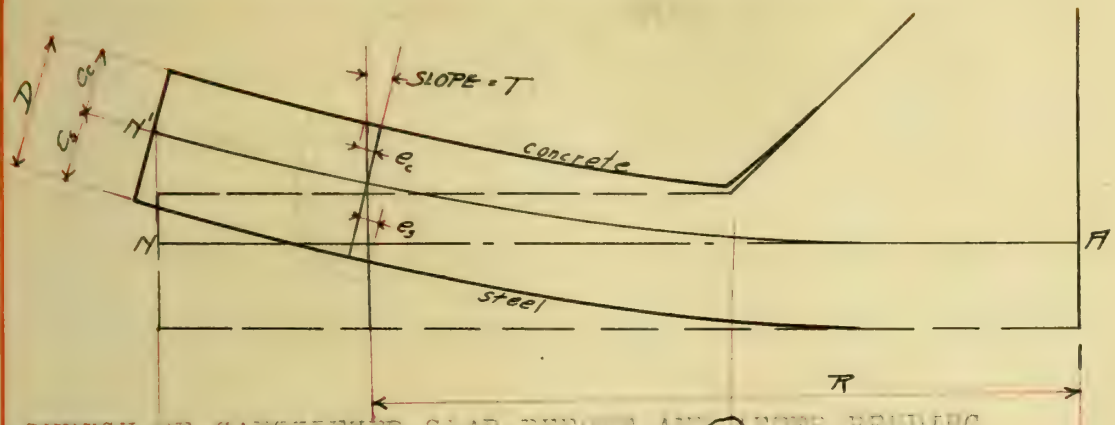
27. Relation between stresses in Tangential and in Radial Circular Reinforcement. There seems to be no appreciable difference in the deformations of the welded hoops in slabs 1255 and 1256, from those deformations in the rectangular rods crossing a diametral section at the same point. A difference is not very greatly to be expected since at the points where both these kinds of rods cross a diametral section , they are running in the same direction. Reasoning from the elastic theory, the radius of curvature of the plate cannot have more than one value for any point when the direction of the radius or its plane is determined..

28. Effect of the distribution of Steel over the section of a slab on the distribution of the Concrete deformations over the same section. Some authorities on flat slab action have argued that steel cannot be used efficiently if not distributed uniformly over the section which is considered as resisting the bending moment developed. A comparison of the circumferential deformations perpendicular to a radial section, for the slabs without welded hoop reinforcement and those with the same, gives no indication of any essential difference in their distribution. The fact that most of the steel cutting a diametral section in slabs 1256 and 1255 is concentrated at about one-half the distance between the edge of the cap and the outside edge of the slab, seems to have the very same effect on stress-distribution in the concrete as uniform distribution of the steel in the other slabs has.

5%. Suggestions for the design of future experiments. One important phase of this series of tests which has not yet been touched upon is the effect of varying percents of steel. It seems quite evident from the tests made in the last two years that .60 % of steel is considerably below the balanced percent of steel which is necessary to develop the full strength of the concrete. However, if the slabs are made much stronger it will be impossible to break them without danger to the testing machine. Another point concerning which something might well be found out is the effect of drop. The action of the drop on slab 1252 in shearing off at the ultimate load indicates that high shearing stresses must exist in the horizontal plane between ~~the~~ the drop and the bottom of the slab.

C. THEORY AND ANALYSIS.

20. The Relation between the Slope of the Elastic Curve along a radius and the Circumferential Deformations.



SKETCH OF CANTILEVER SLAB BEFORE AND AFTER BENDING

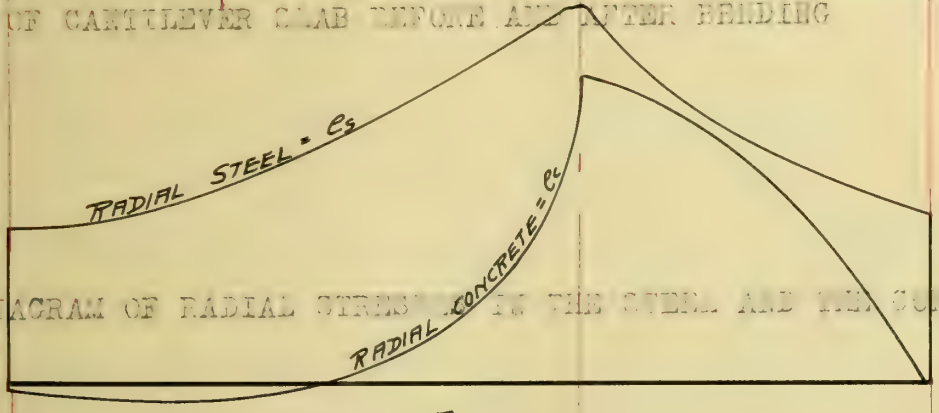


DIAGRAM OF RADIAL STRESSES IN THE STEEL AND THE CONCRETE

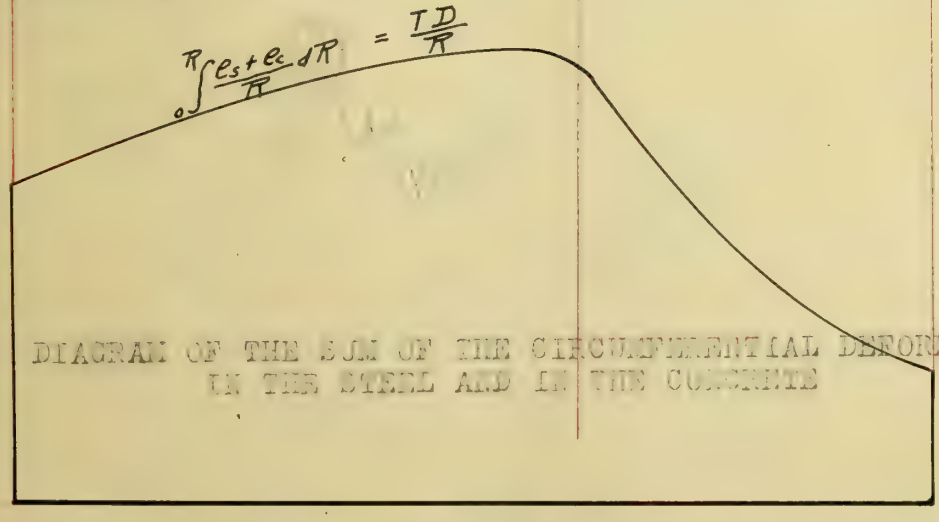


DIAGRAM OF THE SUM OF THE CIRCUMFERENTIAL DEFORMATIONS IN THE STEEL AND IN THE CONCRETE

For geometrical reasons and from the very nature of the distortions occurring, the unit deformation perpendicular to any radius varies directly as the slope of the elastic curve of a section along

a radius, and inversely as the distance from the center of the slab to the point considered,-or the radius.

Let NA and N'A be the location of the neutral axis of the slab before and after bending respectively.

N'A will then be the elastic curve of any section along the radius above referred to.

Let T and D equal the slope of the elastic curve and the depth of the slab respectively.

Let R equal the radius of the circumferential fiber at any point where the circumferential deformations are desired and let r equal the variable value of any radius from the center of the slab up to the radius R.

Let e_s and e_c be the unit deformations of the steel and of the extreme fiber of the concrete, respectively.

Let c_c and c_s be the distance from the neutral axis to the extreme fiber of the concrete and to the steel respectively.

Let E and I be the modulus of elasticity of the material and the moment of inertia of the resisting section respectively.

In this discussion as well as in the common elastic theory, the length of the neutral axis after bending projected upon its length before bending is assumed to be the same as the original length. Therefore it is evident that the total change in length of any radius is equal to cT. The total change in length of any extreme circumferential fiber is therefore equal to $2\pi cT$.

We know that the slope T equals $\int_0^R (M/EI)\, dr$

M equals the bending moment. Its value however, need not be determined since the value of M/EI will be transformed to $(e_s + e_c)/D$.

M/EI equals (unit stress)/Ec equals e/c.

e_s/c_s equals e_c/c_c equals $(e_s + e_c)/D$. This last expression for

M/EI is best suited for work in reinforced concrete since it introduces only the two variables e_s and e_c.

Therefore T equals $\int_o^R [(e_s + e_c)/D \ dr]$ and the total change in length of any extreme circumferential fiber becomes $2\pi c \int_o^R [(e_s + e_c)/D \ dr]$ Then dividing by $2\pi R$ to get the unit circumferential deformation on an extreme fiber we get $c/R \int_o^R [(e_s + e_c)/D \ dr.]$ This expression holds for both the steel and the extreme concrete fiber. By simple addition we get that the sum of the unit circumferential deformations for both extreme fibers equals $(e_c + e_s)/R \int_o^R [(e_s + e_c)/D \ dr.]$ When the depth is constant the value of $(e_c + e_s)$ outside the integral cancels the value of D inside the integral and the expression takes the convenient form $^{one}\ 1/R \int_o^R [(e_c + e_s) \ dr]$. This formula shows that the sum of the extreme fiber circumferential deformations at any point is a function of the average of the radial deformations from the center of the slab up to the point considered.

The curves on the following sheets which are drawn to show these relations, in most cases give a satisfactory check. One fact which makes it difficult to get an exact sum of the radial curves is that the largest part of the radial deformation in the concrete probably occurs inside of the nearest gage-line to the cap upon which it is possible to take measurements.

For instance, in slab 1254, two values of the sum curves of radial deformation are assumed between the edge of the cap and the center of the slab where it is impossible to read the deformations in the concrete. The sum curve of circumferential deformations which is obtained from curve A gives values which are only slightly greater than those for the circumferential deformations measured in the steel alone.

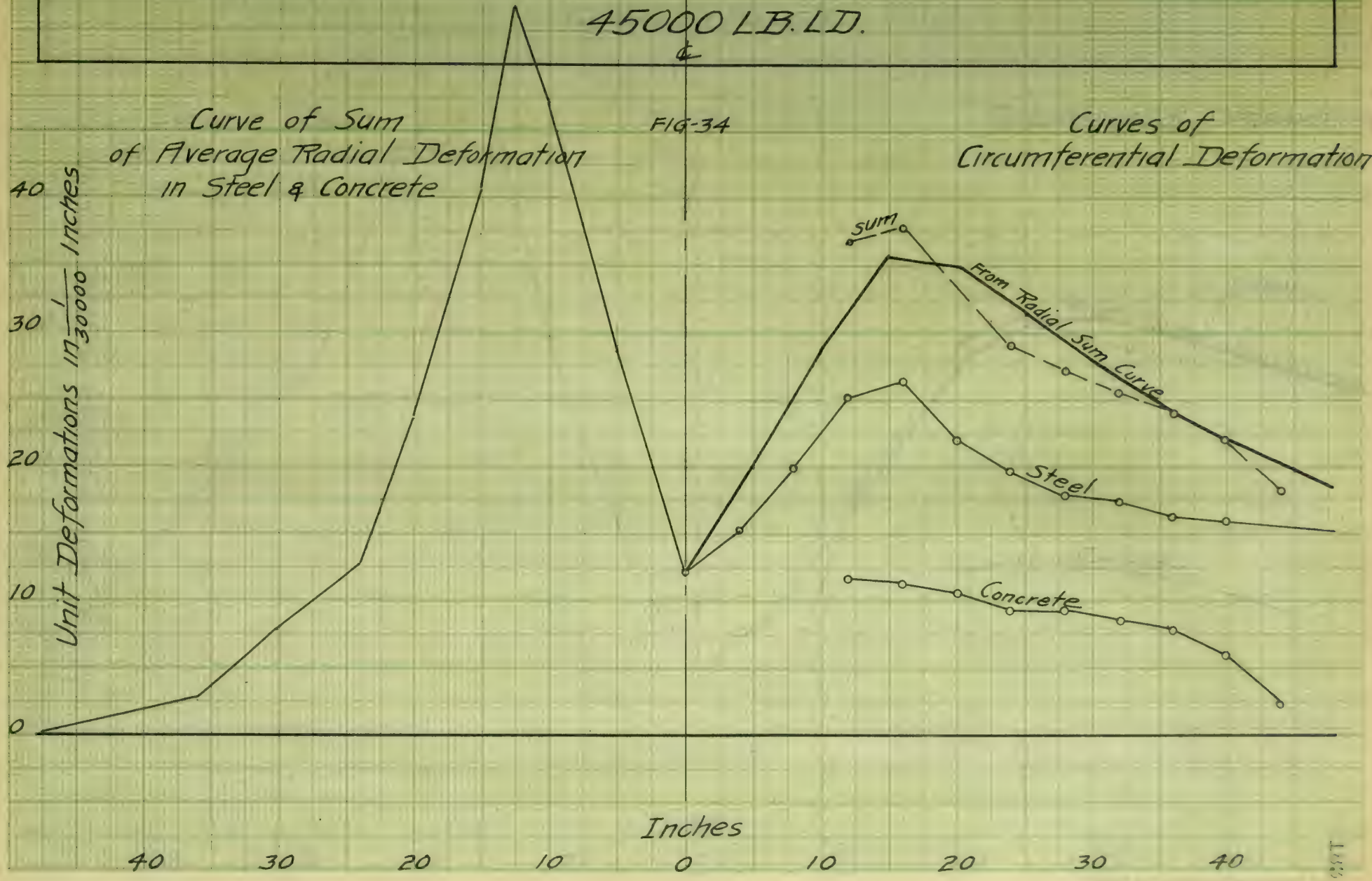
The [illegible] P, for the ratio of the circumferential deformation, which is obtained by averaging the [illegible] P for radial deformations, gives values which [illegible] the actual deformations fairly well.

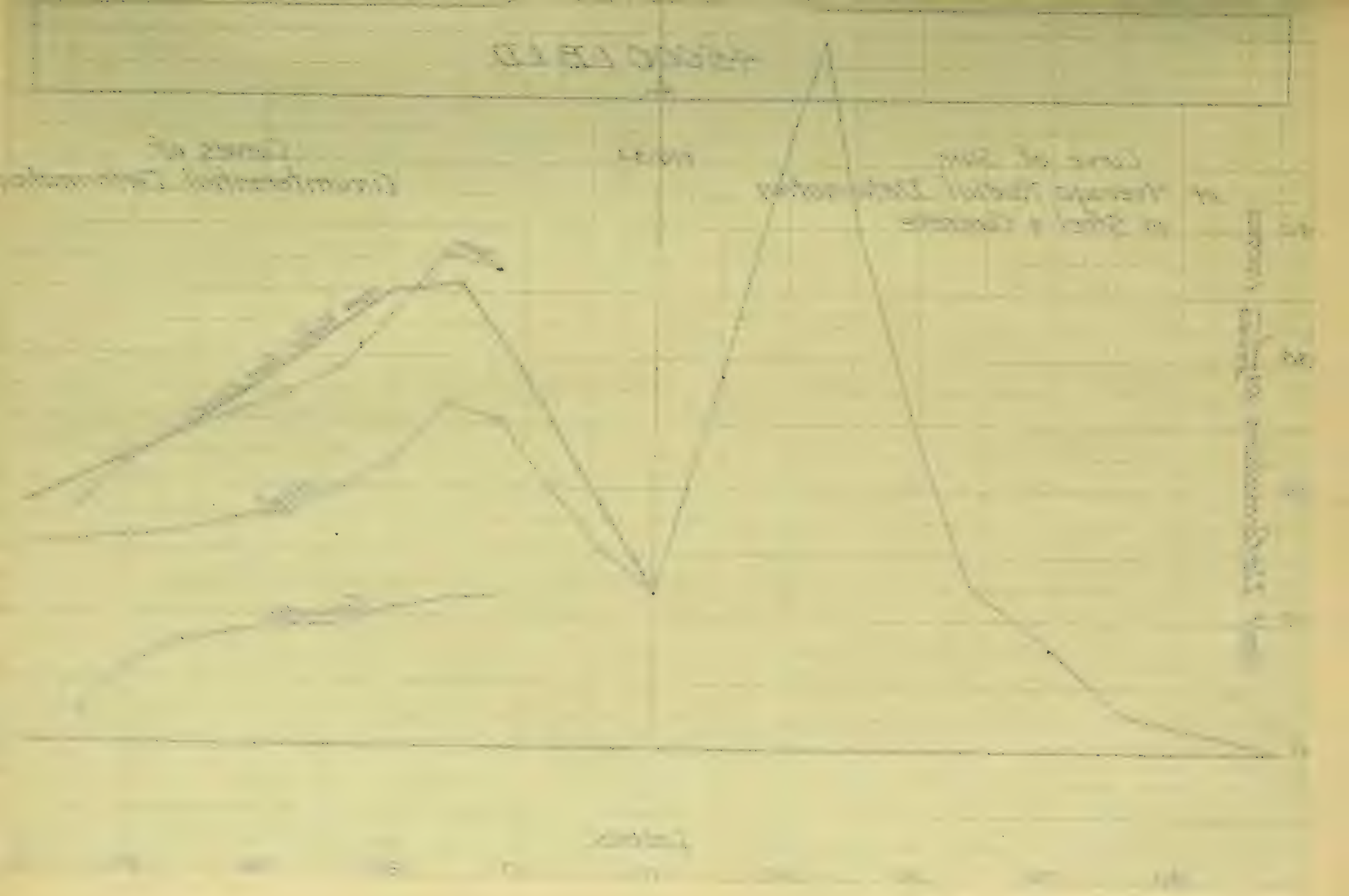
The [illegible] included in the following [illegible] this relation between the radial and the circumferential deformations; [illegible] to agreement with the [illegible] explains the distribution of these circumferential deformations as well as their actual value.

Slab 1251

45000 LB. LD.

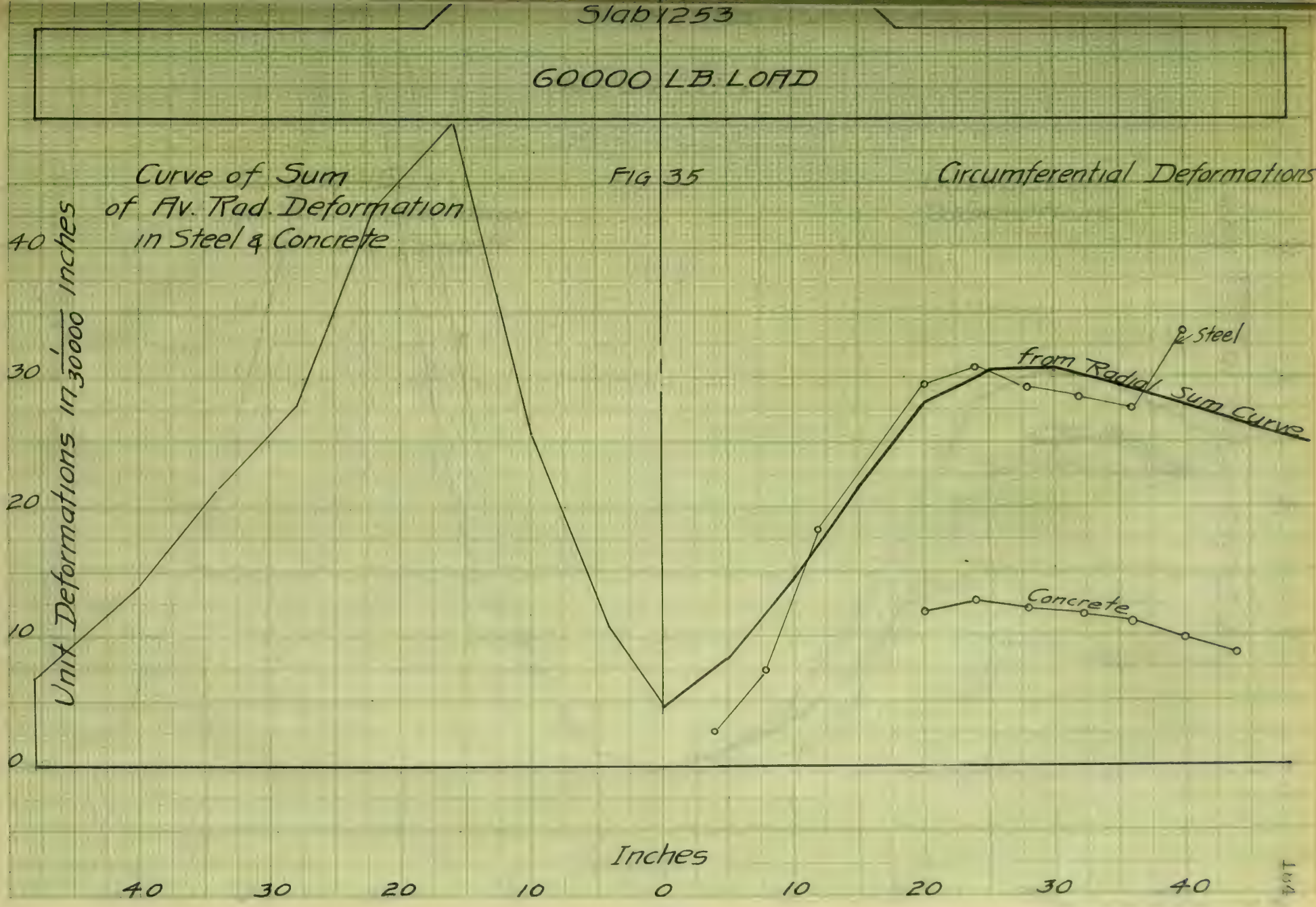
FIG-34

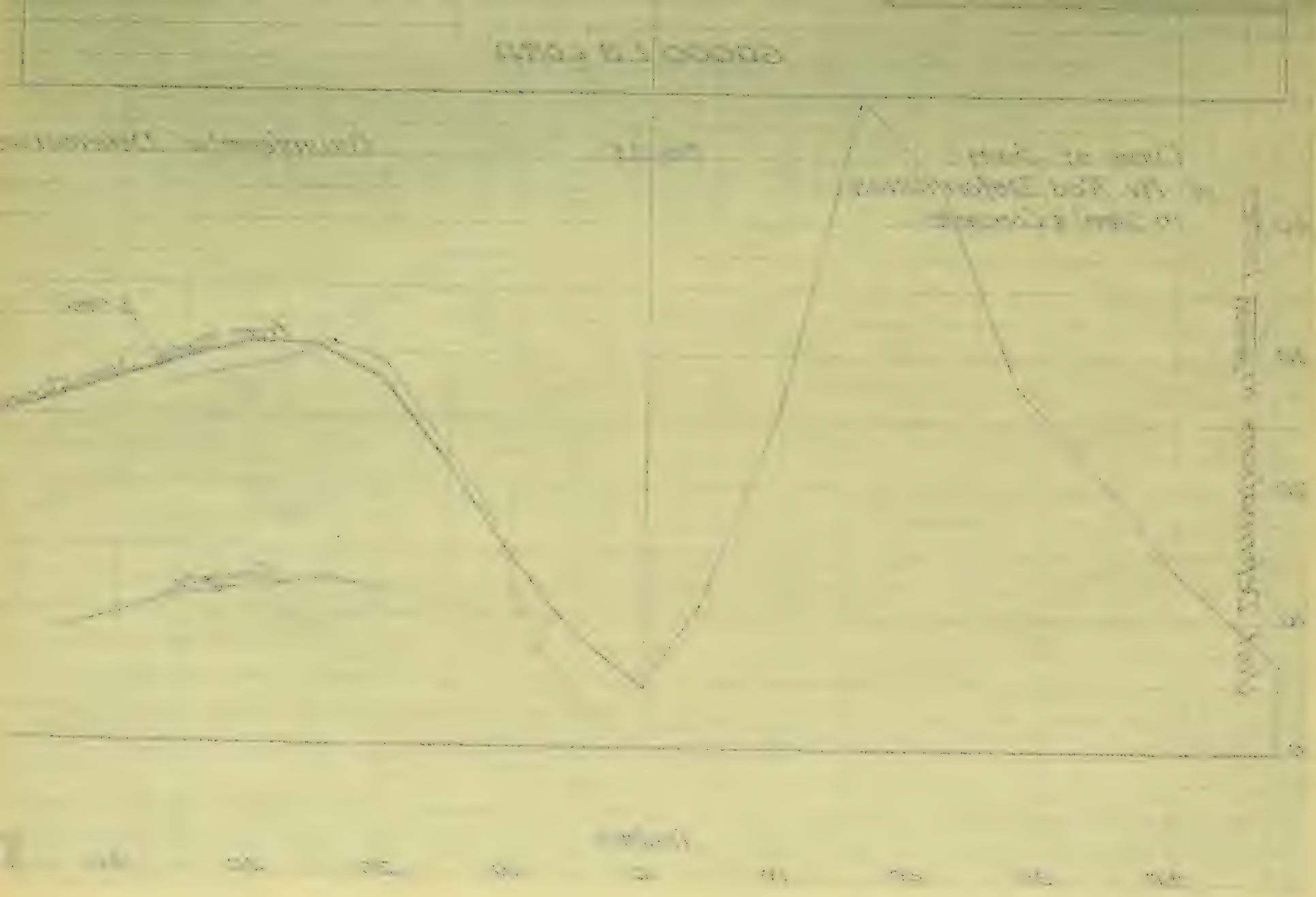


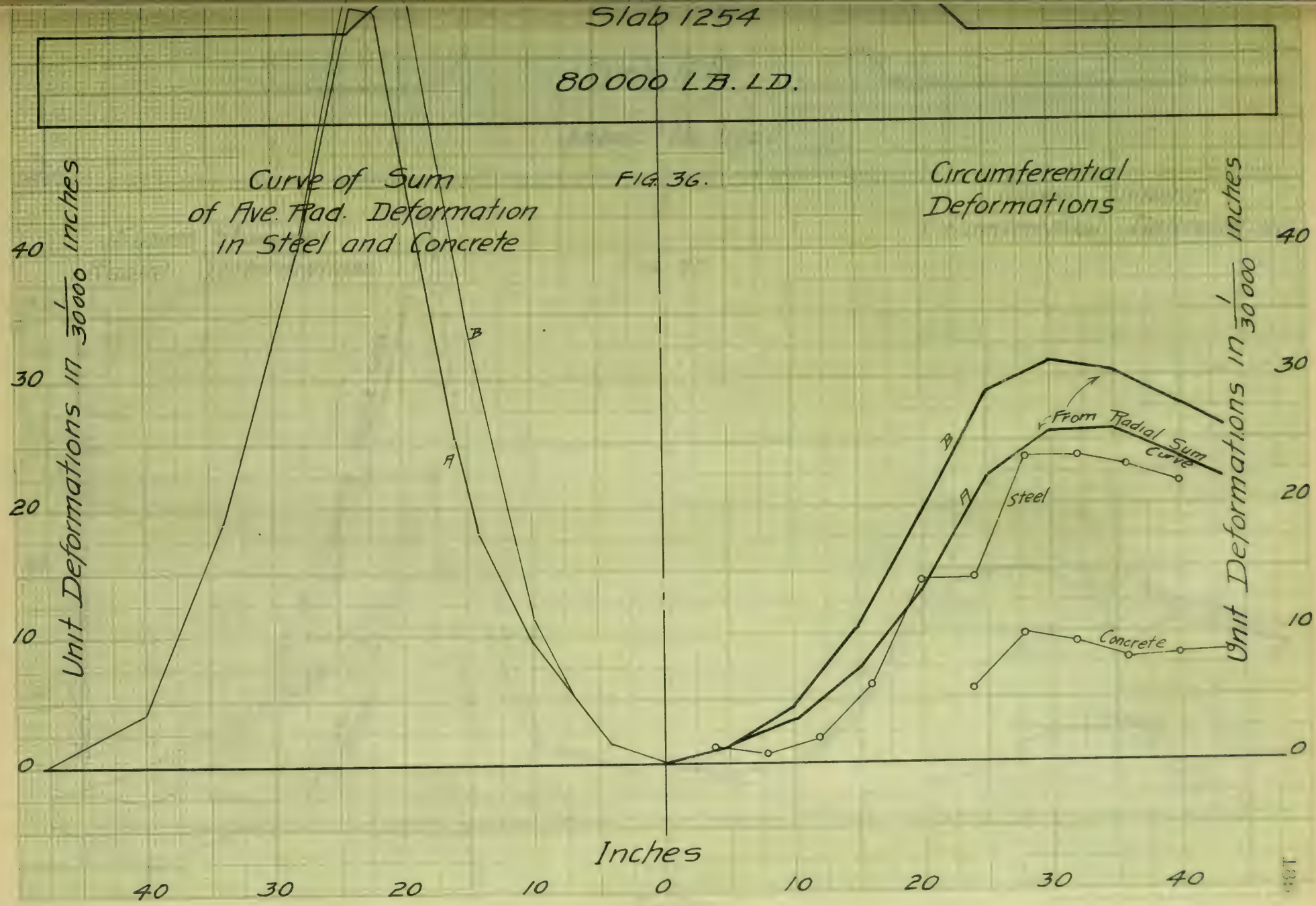


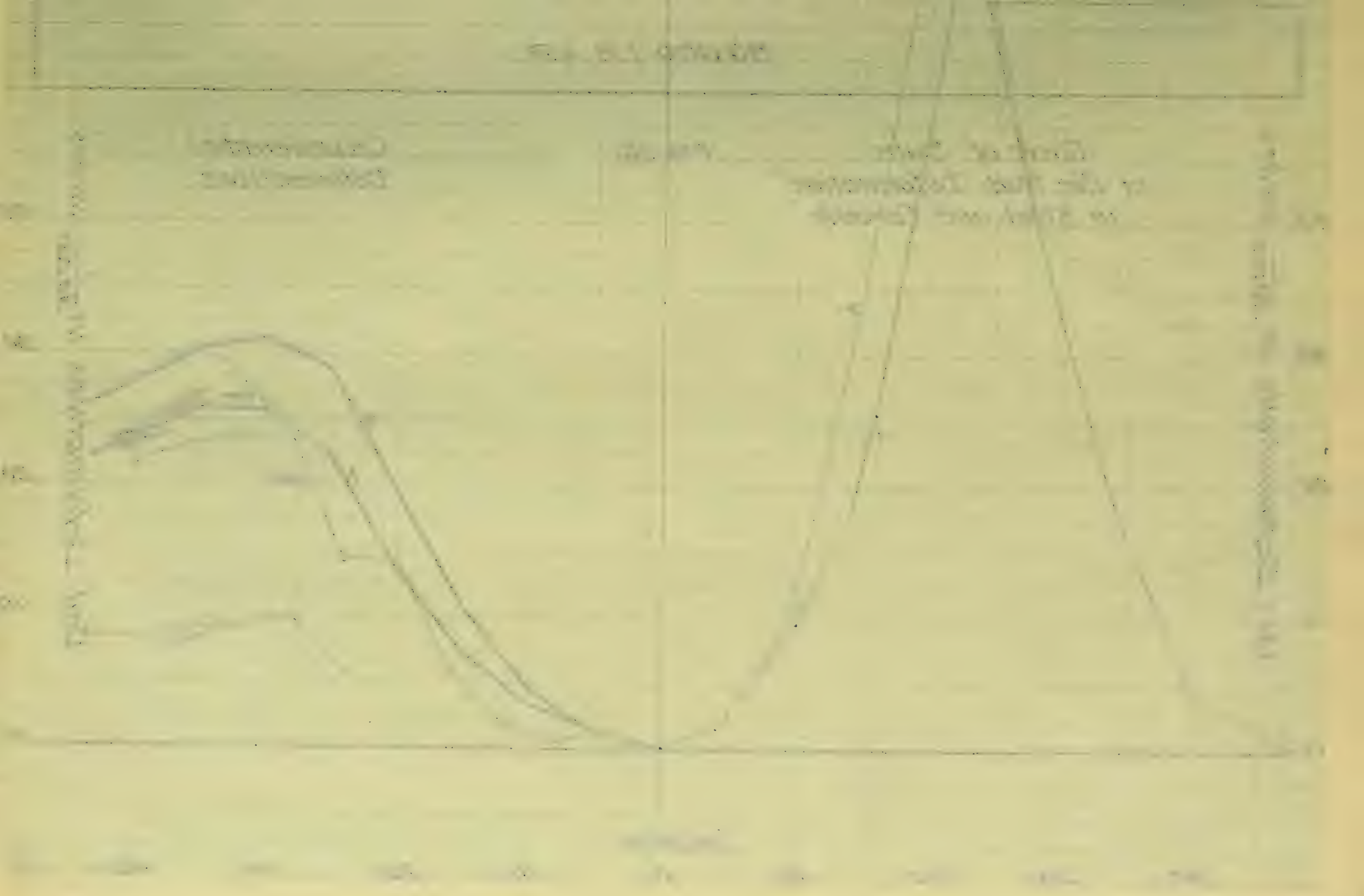
Slab 1253

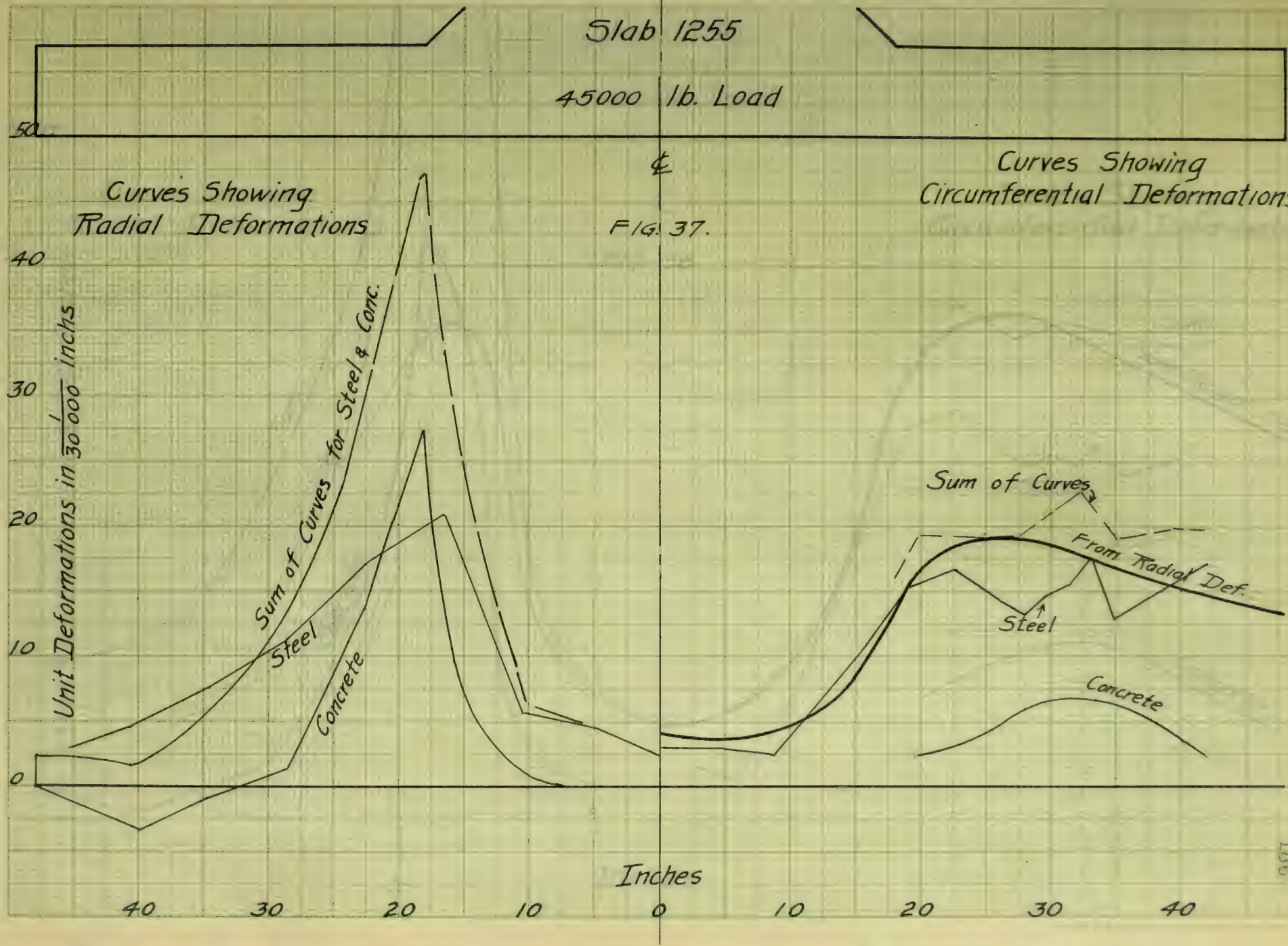
60000 LB. LOAD

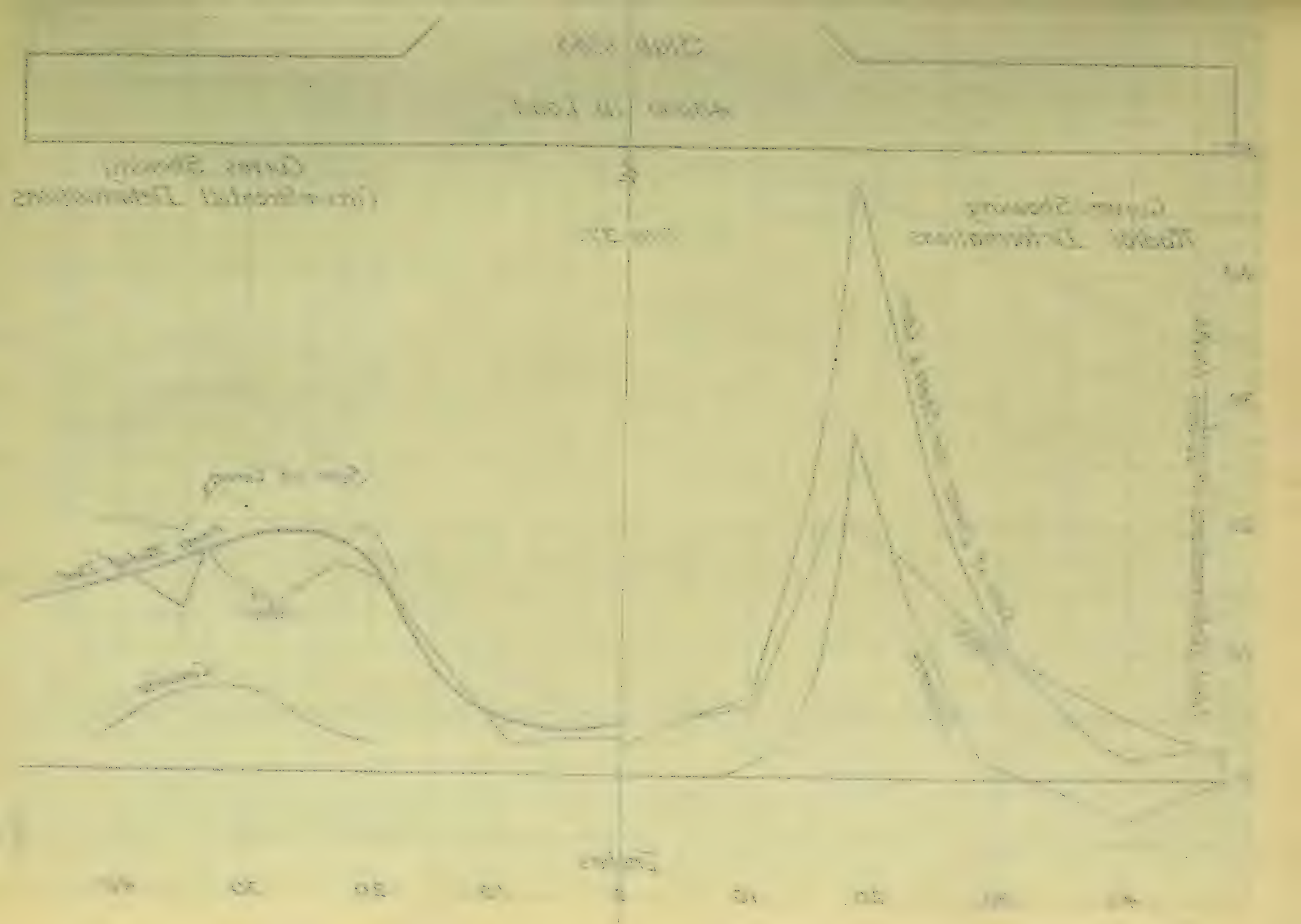


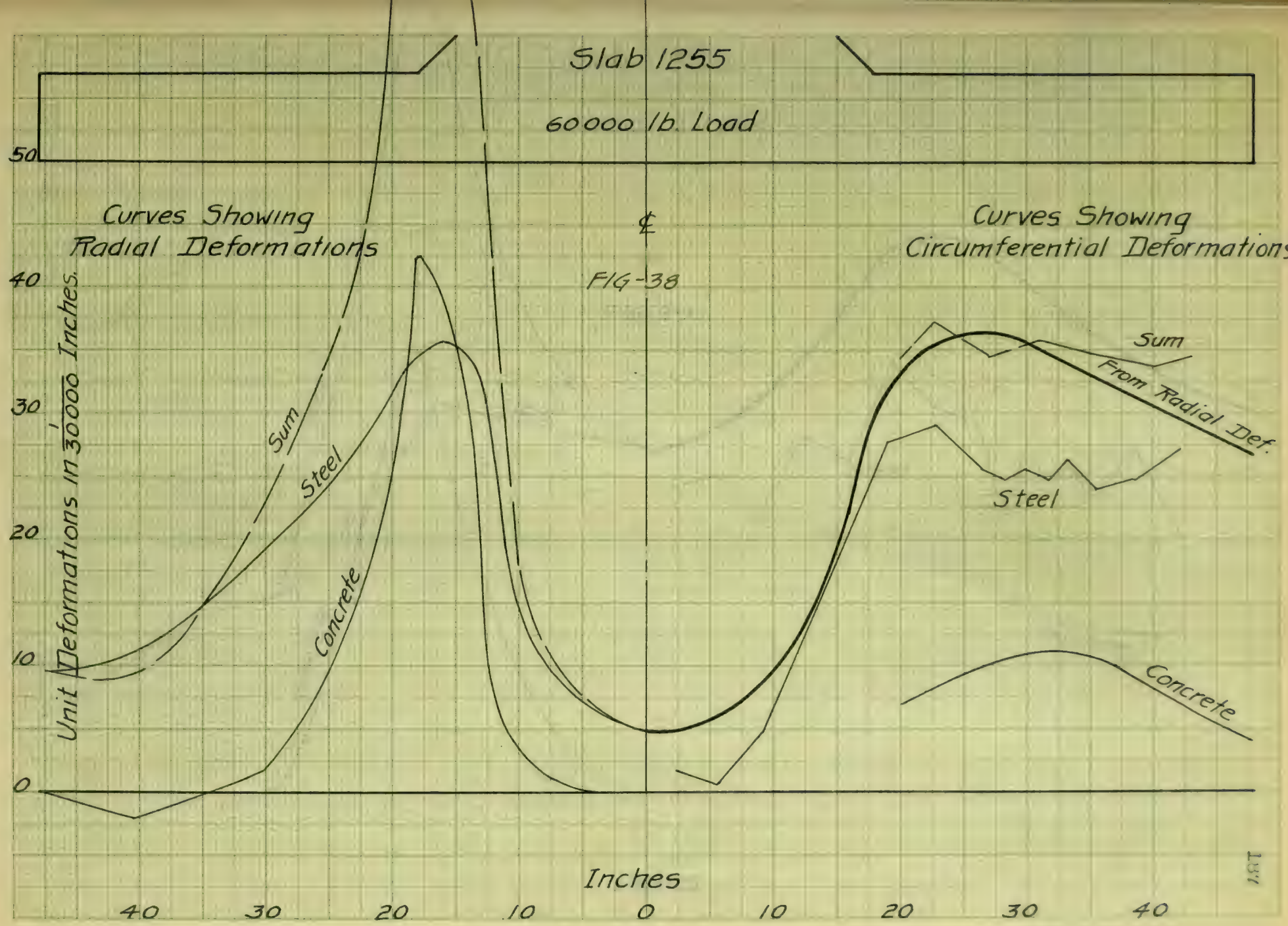


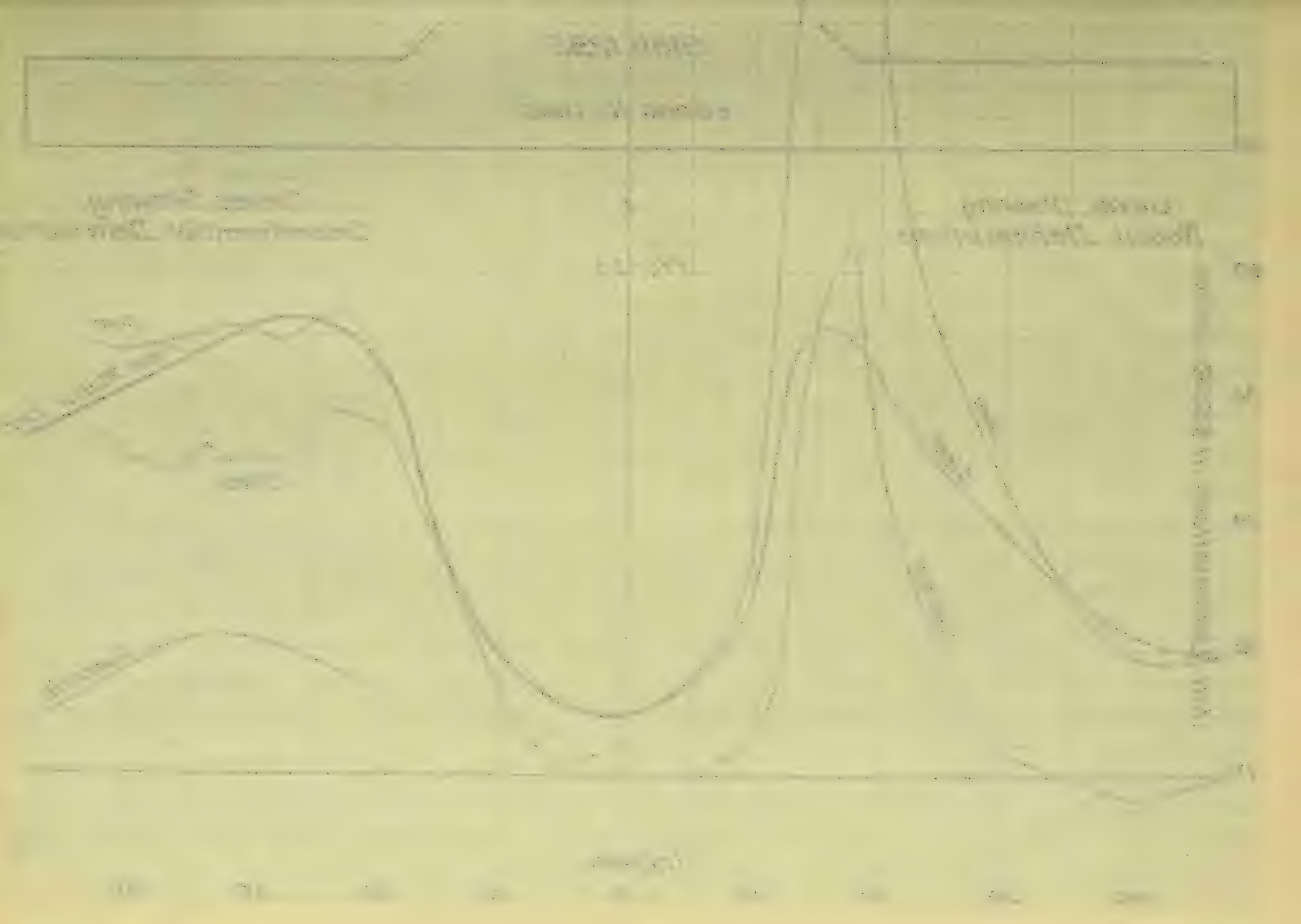

Slab 1254
80 000 LB. LD.
Curve of Sum of Ave. Rad. Deformation in Steel and Concrete
FIG. 36.
Circumferential Deformations
Unit Deformations in 1/30000 inches
Unit Deformations in 1/30 000 inches
40
30
20
10
0
B
A
From Radial Sum Curve
steel
Concrete
Inches
40 30 20 10 0 10 20 30 40

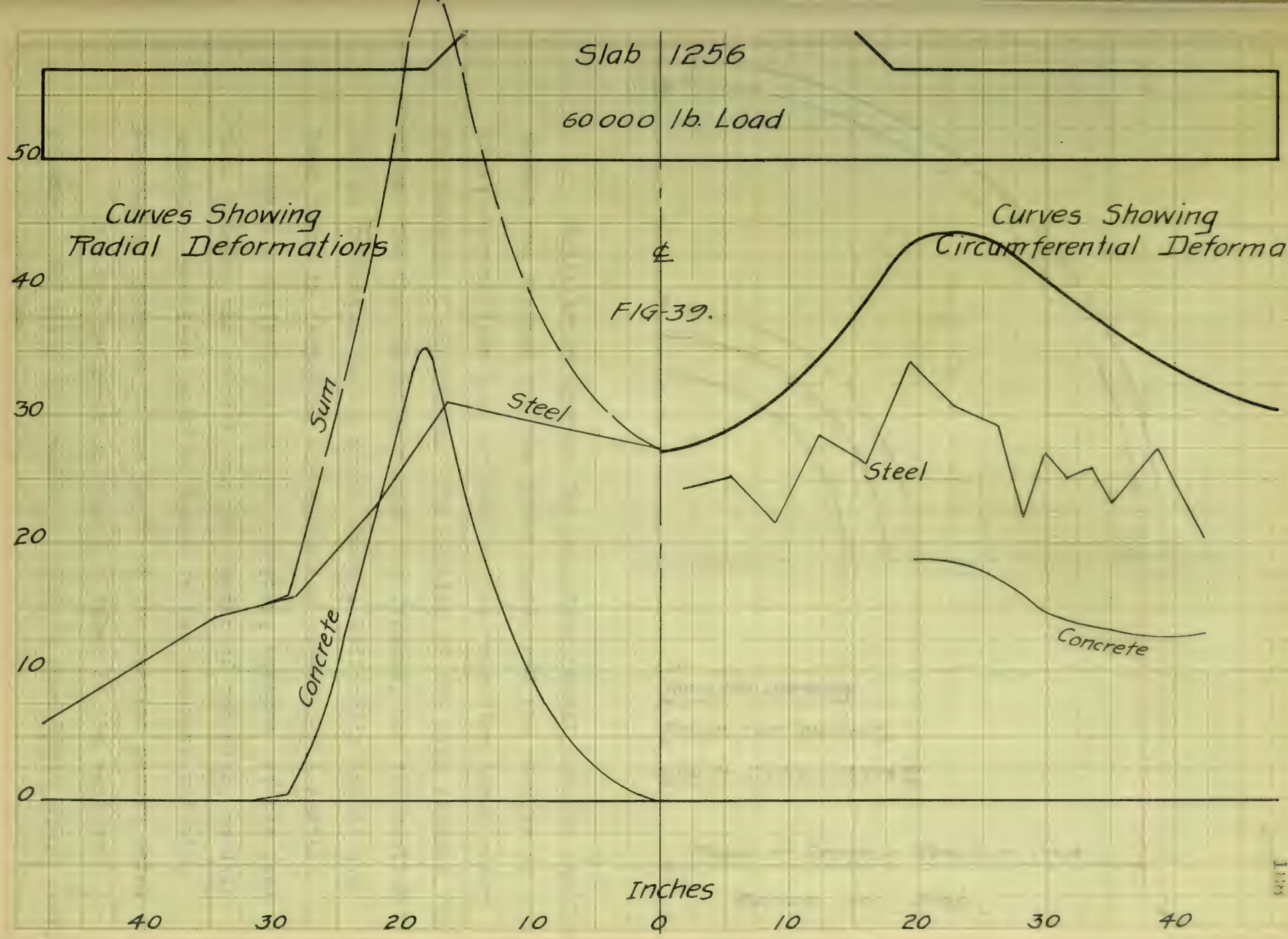


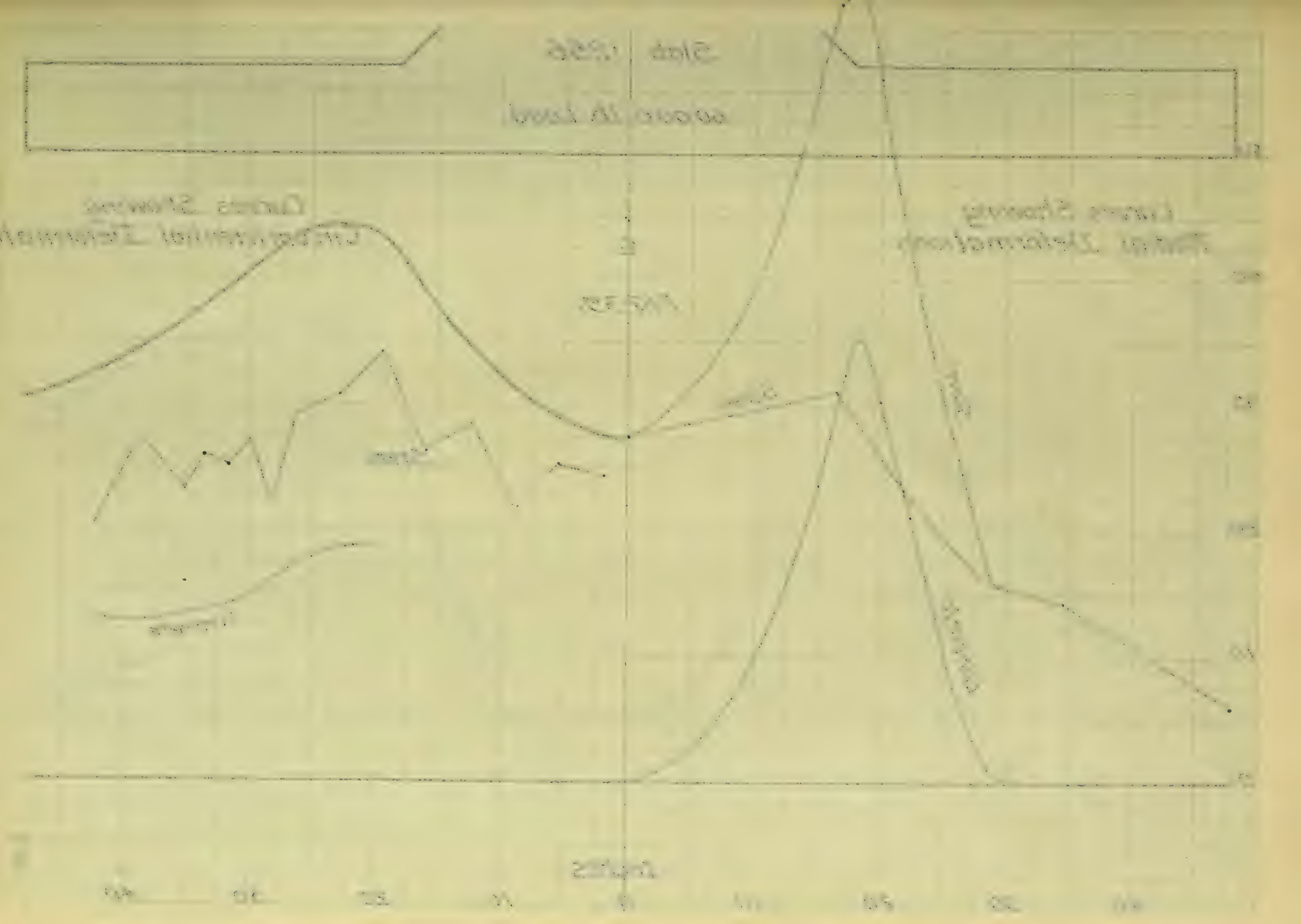

Slab 1255
45000 lb. Load
50
Curves Showing
Radial Deformations
&
Curves Showing
Circumferential Deformations
FIG. 37.
40
30
20
10
0
Unit Deformations in 1/30 000 inchs
Sum of Curves for Steel & Conc.
Steel
Concrete
Sum of Curves
From Radial Def.
Steel
Concrete
Inches
40
30
20
10
0
10
20
30
40

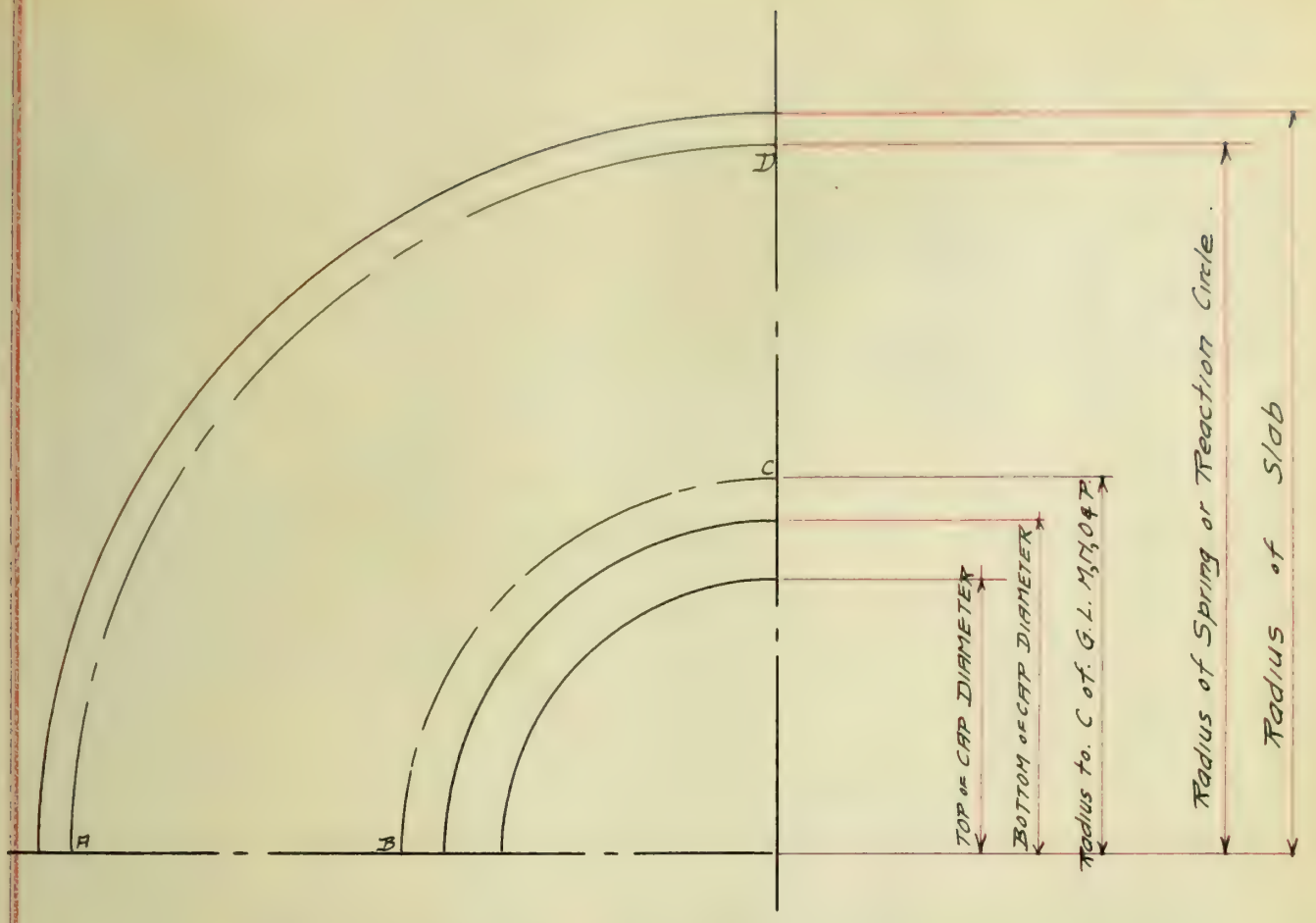



Slab 1255
60000 lb. Load
50
Curves Showing
Radial Deformations
℄
FIG-38
Curves Showing
Circumferential Deformations
40
30
20
10
0
Unit Deformations in 30000 Inches.
Sum
Steel
Concrete
Sum
From Radial Def.
Steel
Concrete
Inches
40
30
20
10
0
10
20
30
40




Slab 1256
60000 lb. Load
50
Curves Showing
Radial Deformations
Curves Showing
Circumferential Deformatio
℄
FIG-39.
40
30
20
10
0
Sum
Steel
Concrete
Steel
Concrete
Inches
40
30
20
10
0
10
20
30
40





Equilibrium between the resisting moment and the bending moment was figured for the slabs tested and the results of these computations are included in the preceding pages under the heading of slab data. The section of the slab assumed, for which the the resisting moment was figured, was the section ABC as indicated in the above sketch. Difficulty would have been found in computing the resisting moment for a section which was entirely along the diameter, because of the fact that between the point B and the center of the slab, no deformation readings could be taken in the concrete and also because an increase in the depth of the section occurs here.

All the deformation readings taken on the sections assumed, including the readings taken on gage-lines M,N,O and P,

$\bar{x} = \frac{2r}{\alpha} \sin\frac{\alpha}{2}$

$\alpha = 90°$ $\quad \bar{x} = .707 \times \frac{4r}{\pi}$

$= .900\, r$

$\alpha = 180°$ $\quad \bar{x} = .637\, r$

$= 0.9 \times .707\, r$

are in the direction CD. The results of the readings taken on the gage-lines M,N,O and P, are plotted on the same curves as those circumferential readings (1,2,3,4,5 etc.), which are perpendicular to the diameter. These stresses are differentiated from the stresses in the steel rods at the same distance from the center of the slab, which cut the diameter, by connecting the points on the curve with a dot-dash line.

The bending moment is taken as a couple between the load which is assumed to be uniformly distributed around the arc BC, and the reaction which is assumed to be uniformly distributed along the reaction or spring circle, AD.

Let W, R and r be the total load on the slab, the radius of the spring circle and the radius of the arc BC, respectively. Then the Bending Moment acting on the section ABC in the direction CD , will equal W/4 multiplied by the distance between the centers of gravities of the arcs AD and BC, multiplied by(sin 45°). For all practical cases the distance between the centers of gravities of the arcs and the difference of their radii, are the same. Therefore the bending moment becomes,

.707(R-r)W/4 [illegible] .9(R-r)

.637

As is evident from an examination of the load-stress curves illustrating the the effect of cap-diameter, a large percentage of the slab strength at lower loads is due to tension in the concrete. The equilibrium calculations included in the preceding pages have for their object the determination of the effective depth or the jD of the steel. This is obtained by dividing the bending moment obtained by the above formula by the total steel area times the average stress in the steel

Table IV.

Slab No.	Load Lbs. on slab.	Average Stress in Steel.	Average Stress in Concrete.
1251	30000	7000	350
	[illegible]	21000	[illegible]
1252	30000	6500	
	45000	19000	
	60000	[illegible]	
1253	[illegible]	5000	[illegible]
	45000	16000	850
	60000	30000	1450
1254	[illegible]	[illegible]	[illegible]
	[illegible]	11000	700
	80000	[illegible]	1000
	100000	42500	[illegible]
1255	30000	[illegible]	[illegible]
	45000	16000	650
	60000	27000	950
	[illegible]	42500	[illegible]
1256	30000	4000	450
	[illegible]	15000	900
	60000	27500	1550
	[illegible]	45000	2300
1257	[illegible]	See Data for Slab 1257	
	45000		
	60000		

n is here assumed equal to 10.

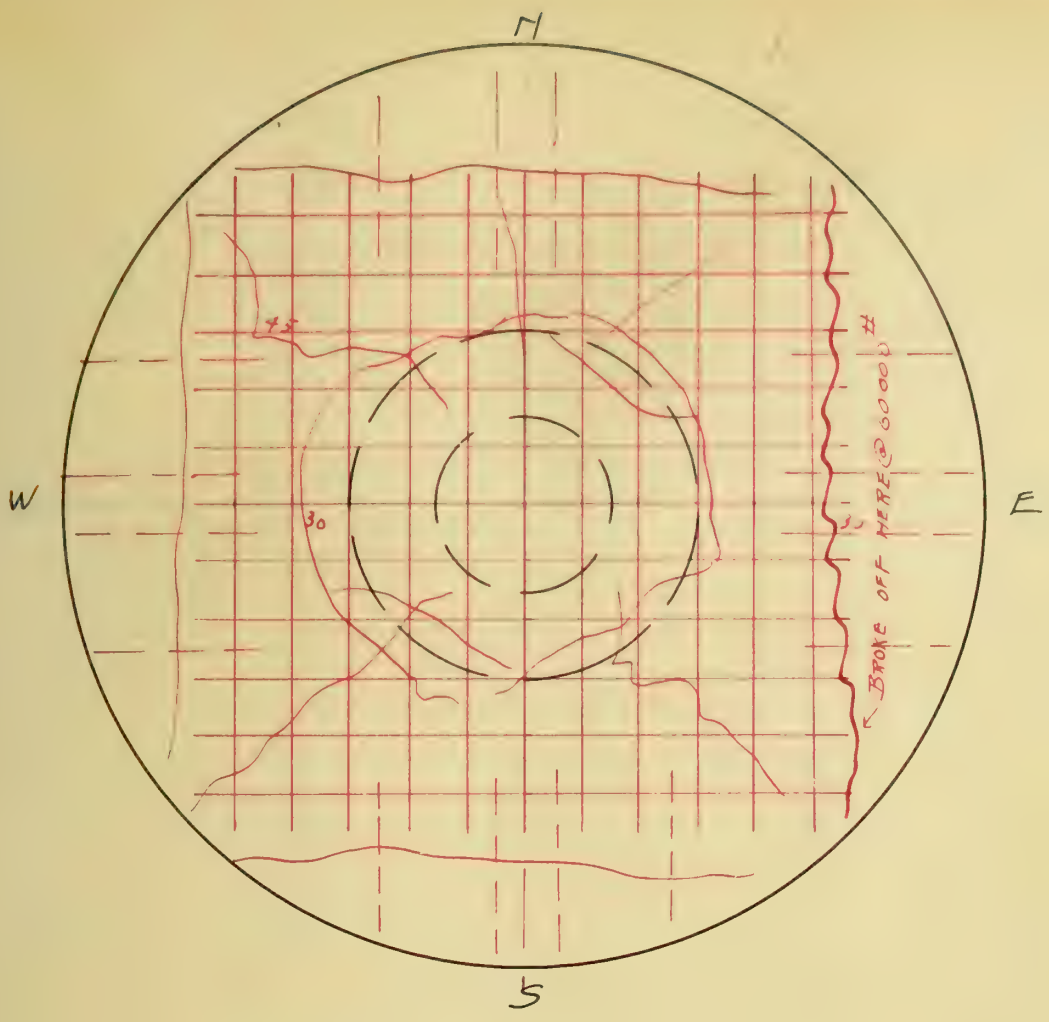
over the section ABC. Because of the fact that in some cases the effective depth obtained is greater than the total depth to the center of gravity of the steel, these calculations indicate that even at high loads the strength due to the tension in the concrete is not entirely lost.

V— Discussion and Data of Test of Slab 1257. The Barton Co. furnished the steel which was used in Slab 1257. This steel was in the form of a square mat with 11- 5/8 " ϕ - Havemeyer bars in each of two rectangular directions. Most of the rods in one direction in this mat are continuous and are made so by bending one long rod at intervals equal to the length of the mat on a bend whose diameter is equal to the spacing of the bars in the mat. After being bent in this fashion the rods are bent up at the ends at an angle of 45 degrees as indicated in the sketches.

The sectional area of the steel in one direction in this mat is 3.36 sq. inches which practically is the same sectional area used in all the other specimens tested.

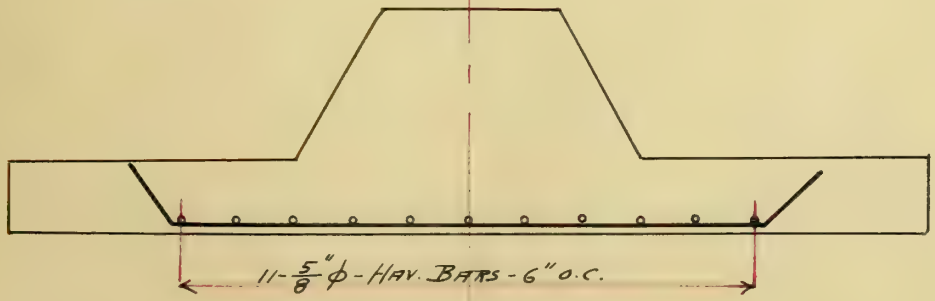
This slab failed at a load of 70000 pounds which was considerably less than the maximum loads of the other slabs with the same amount of steel area cutting a section. The failure in this case was not ,as in all the others, due to tension in the steel but to the sudden cracking off of the whole segment of the slab outside of the edge of the mat. This happened in spite of the addition of several small looked rods across this section as indicated in the sketch of cracks.

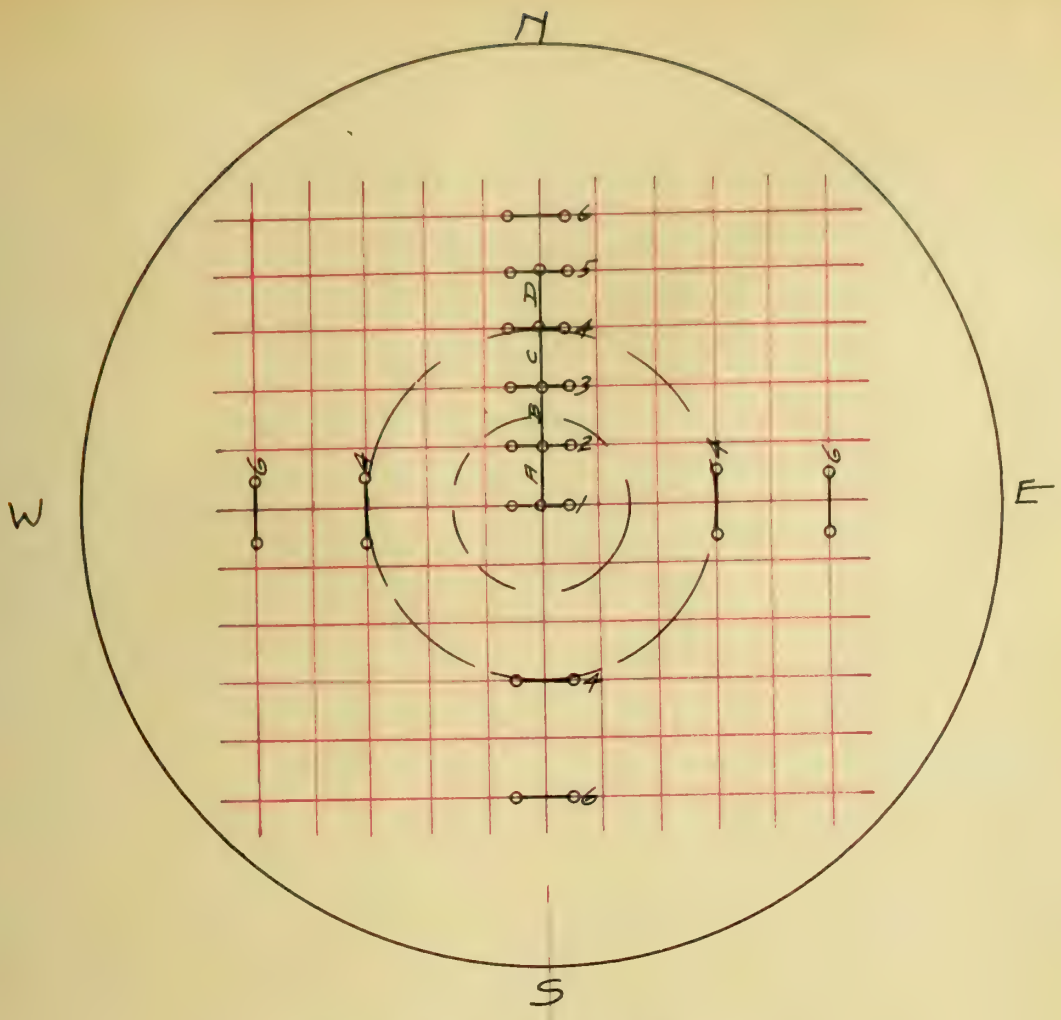
Although readings were taken on a smaller number of gage-lines than on the the other specimens, the curves show much the same distribution of stresses. It is thought that the strength of this kind of specimen would be greatly increased if some of the main rods of the mat extended to the edge of the specimen instead of stopping where they do.



Sketch of Cracks. Slab 1257.

Figure 40.

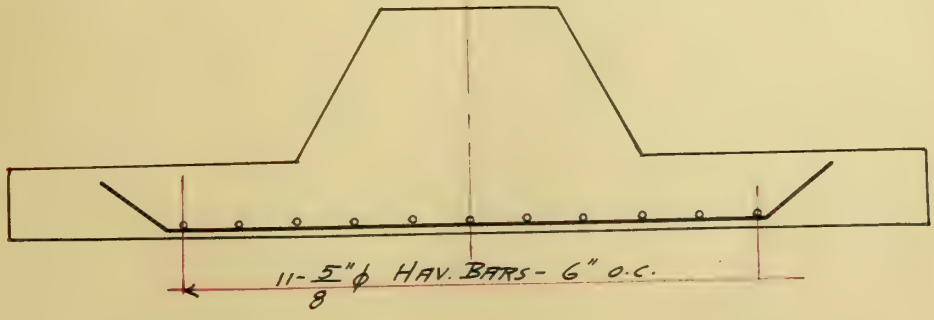


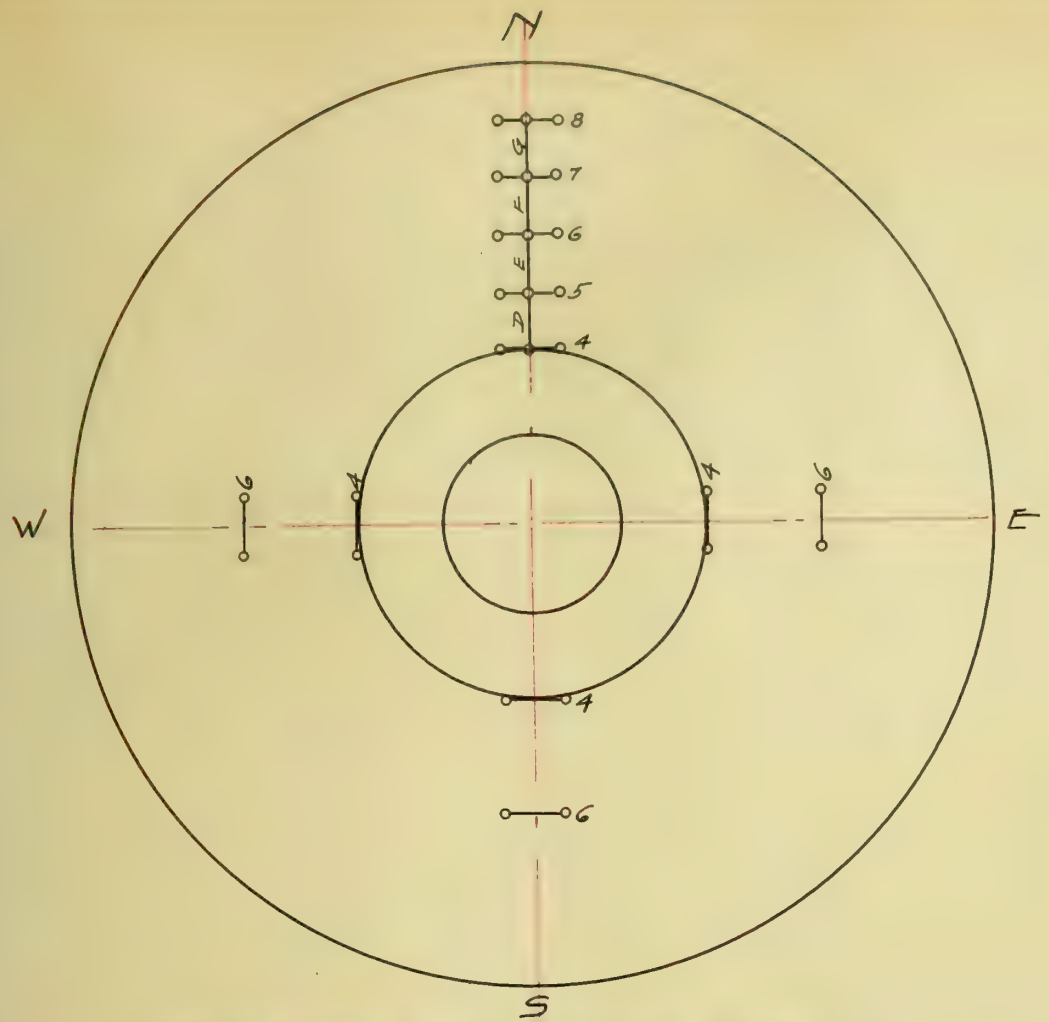


Gage Lines in the Steel.

Slab 1257.

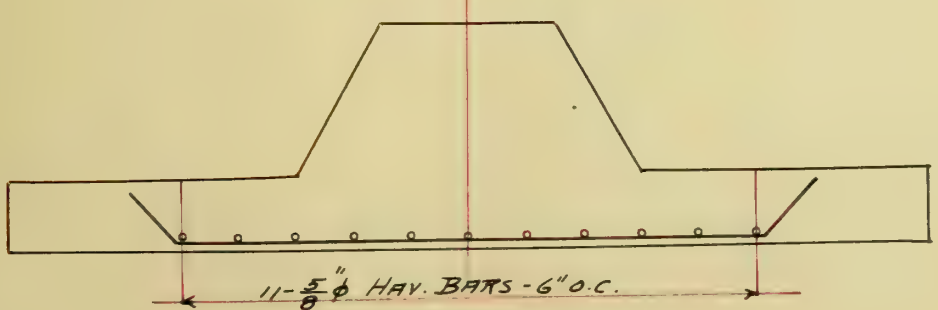
Figure 41.

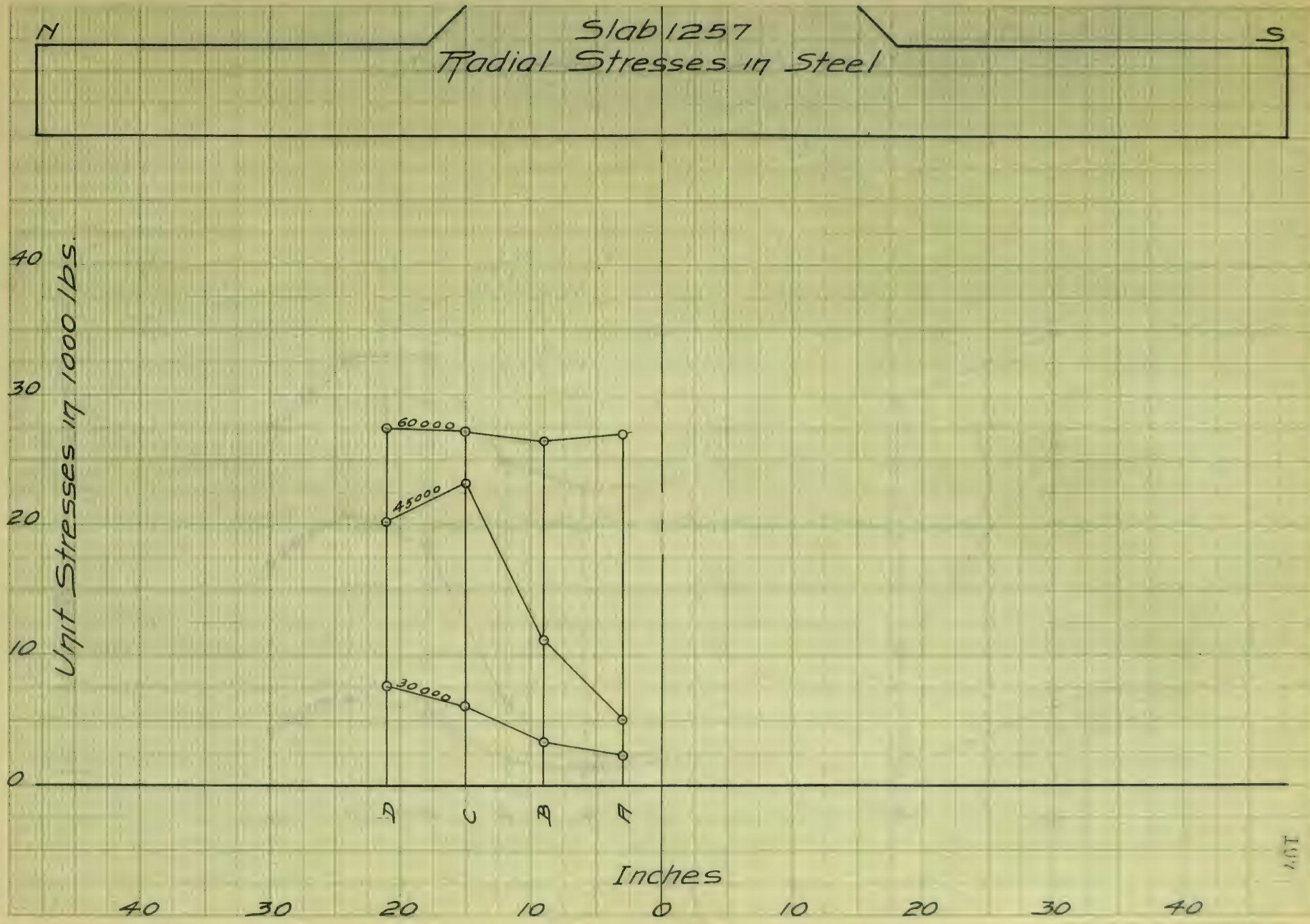


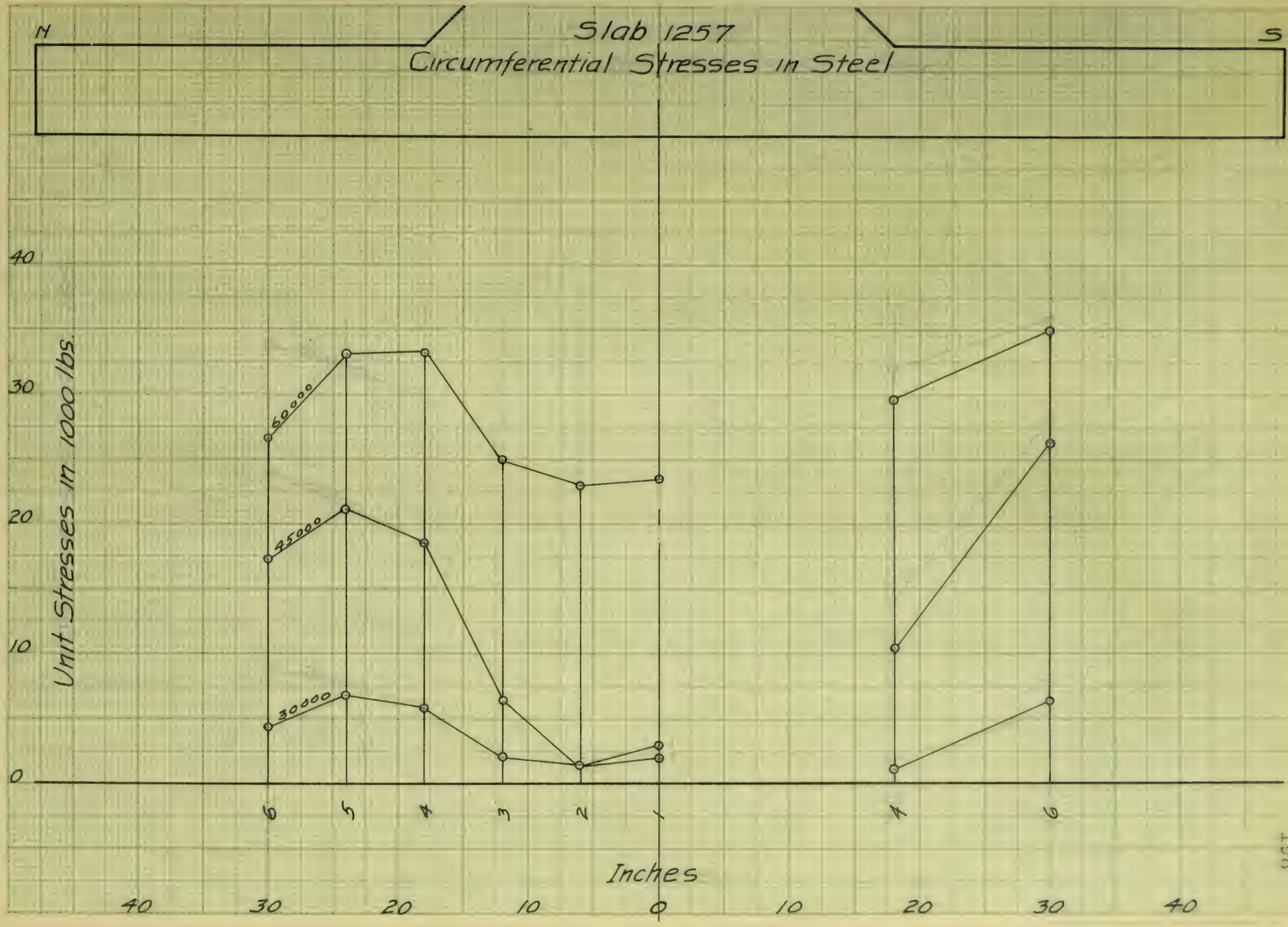


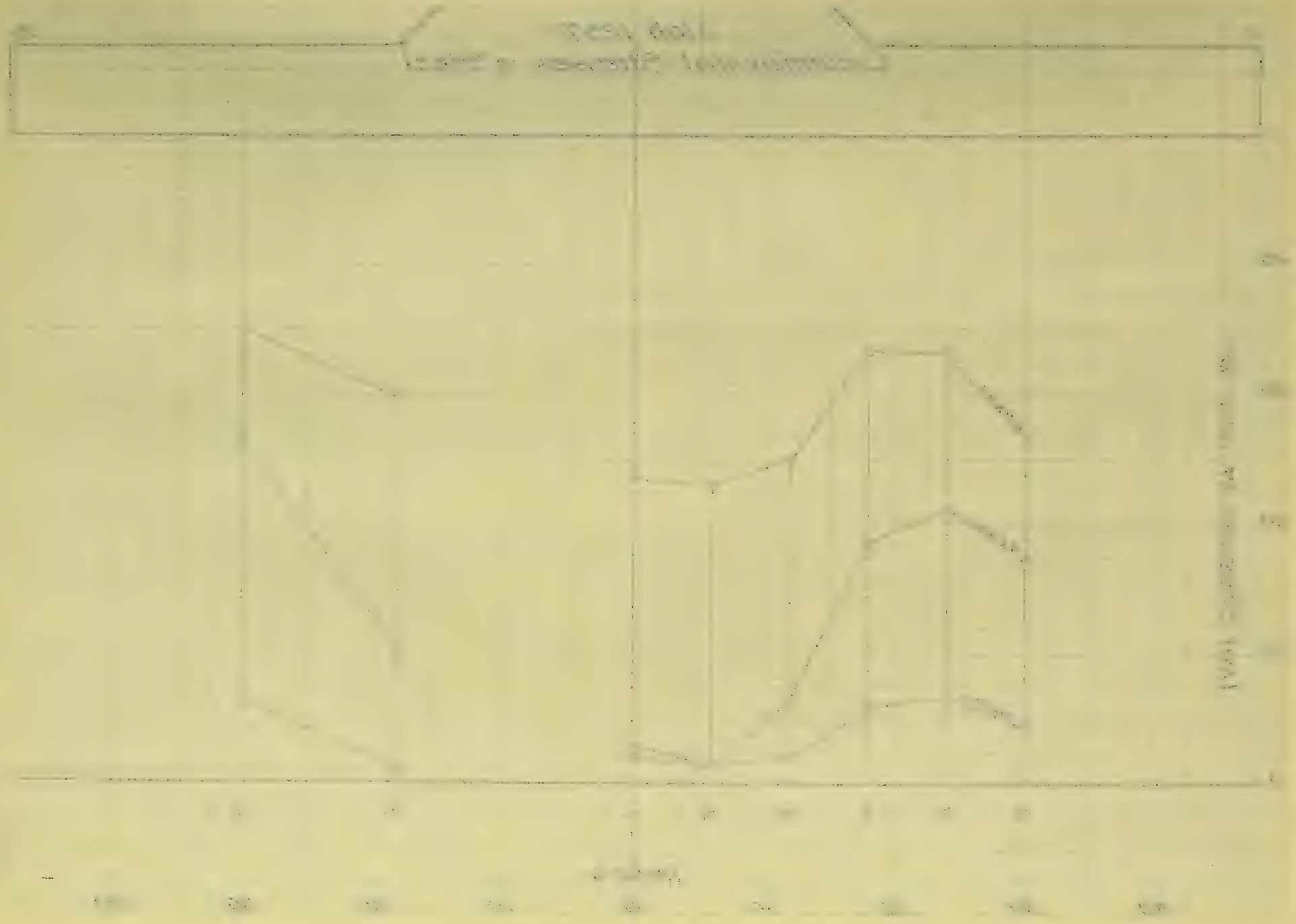
Gage Lines in the Concrete, Slab 1257.

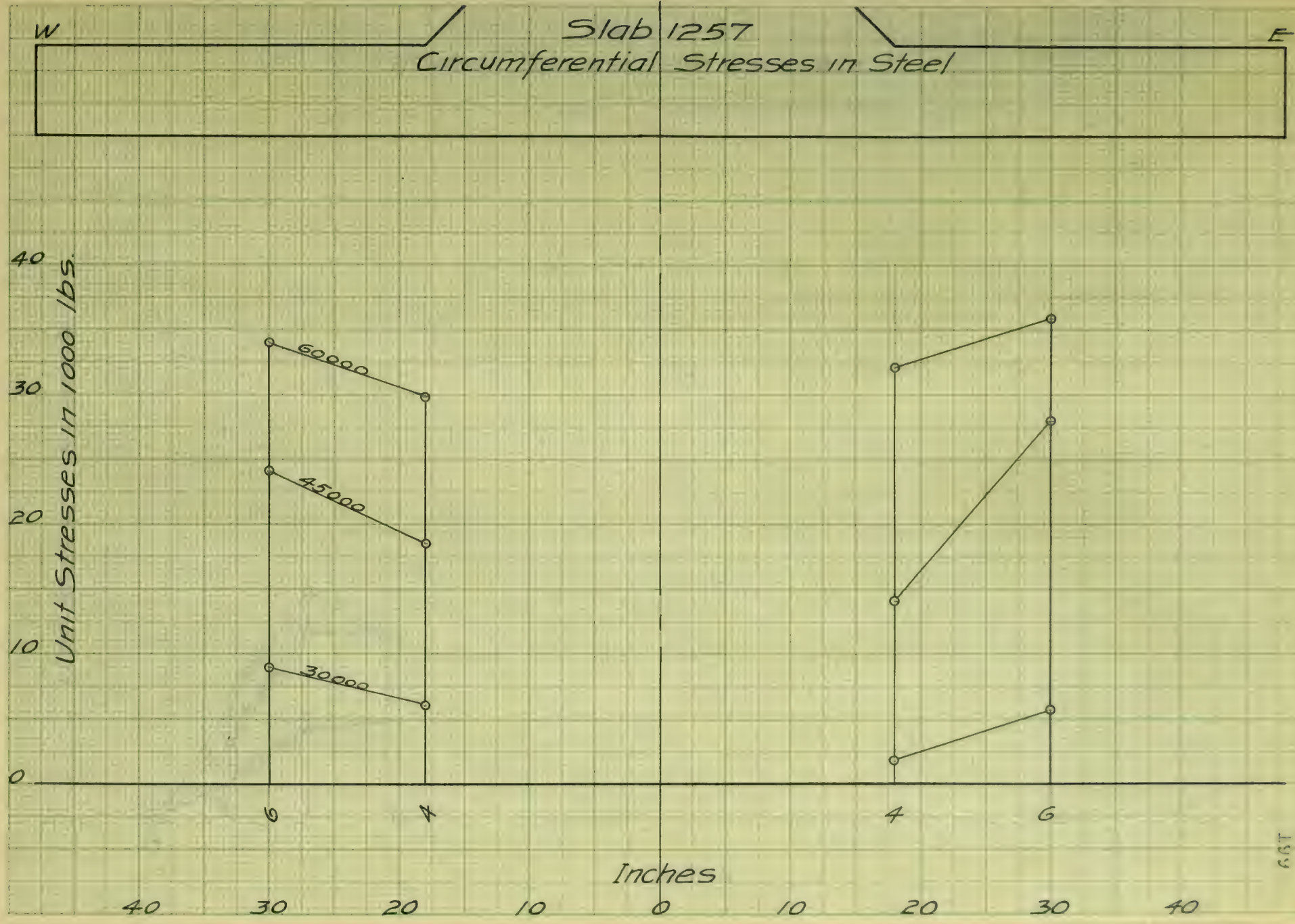
Figure 42.

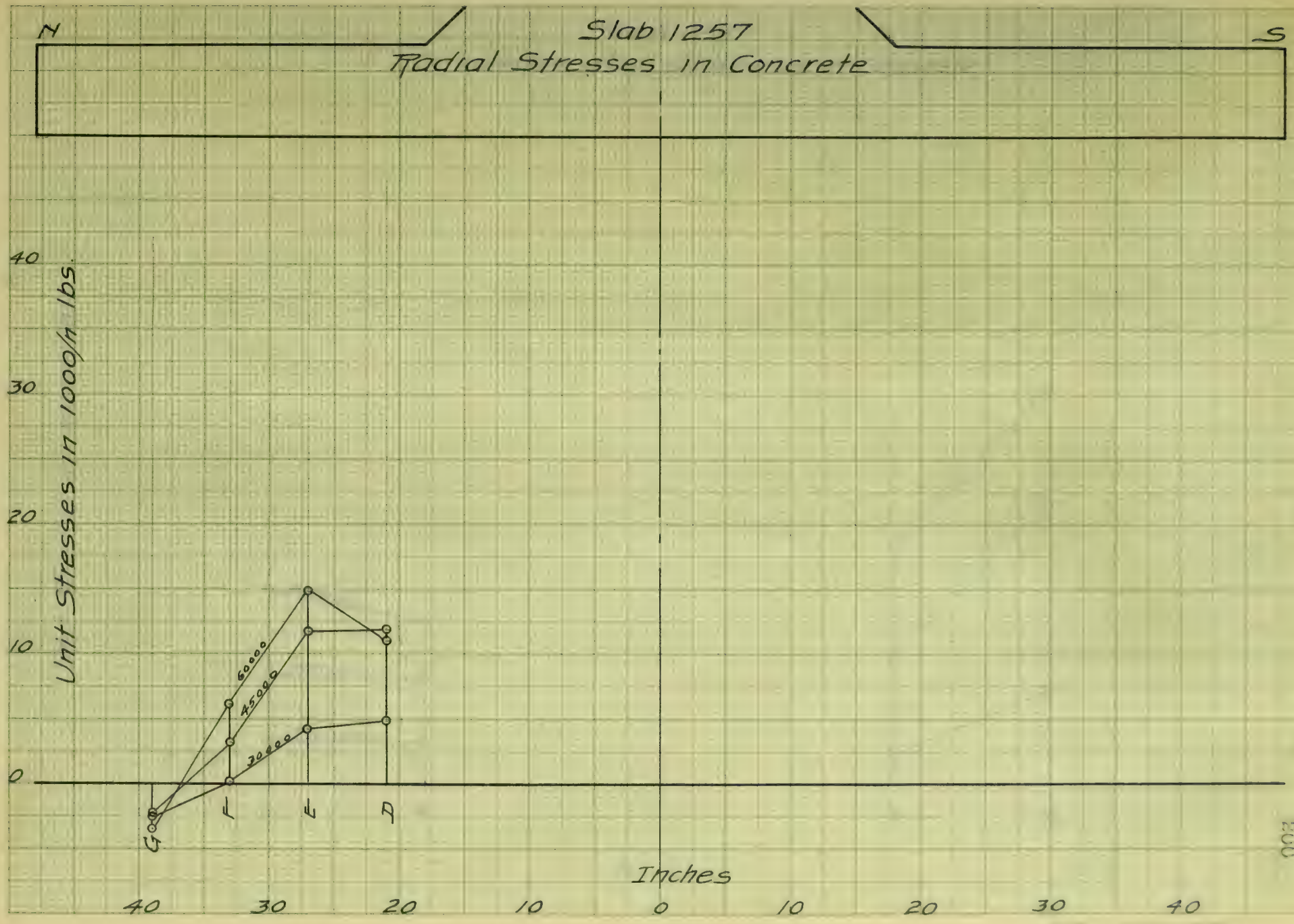


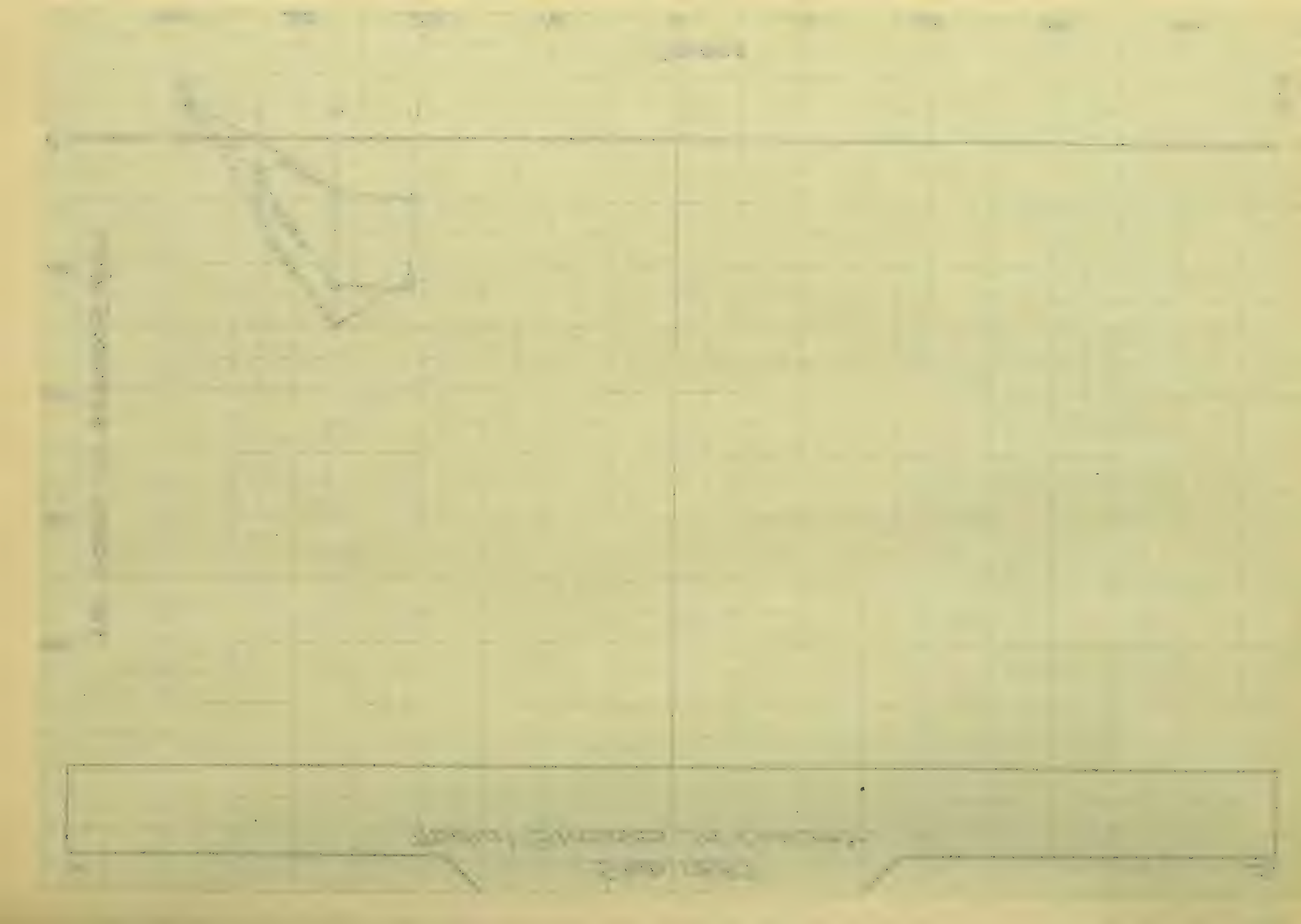

N
S
Slab 1257
Radial Stresses in Steel
Unit Stresses in 1000 lbs.
40
30
20
10
0
60000
45000
30000
D
C
B
A
Inches
40
30
20
10
0
10
20
30
40

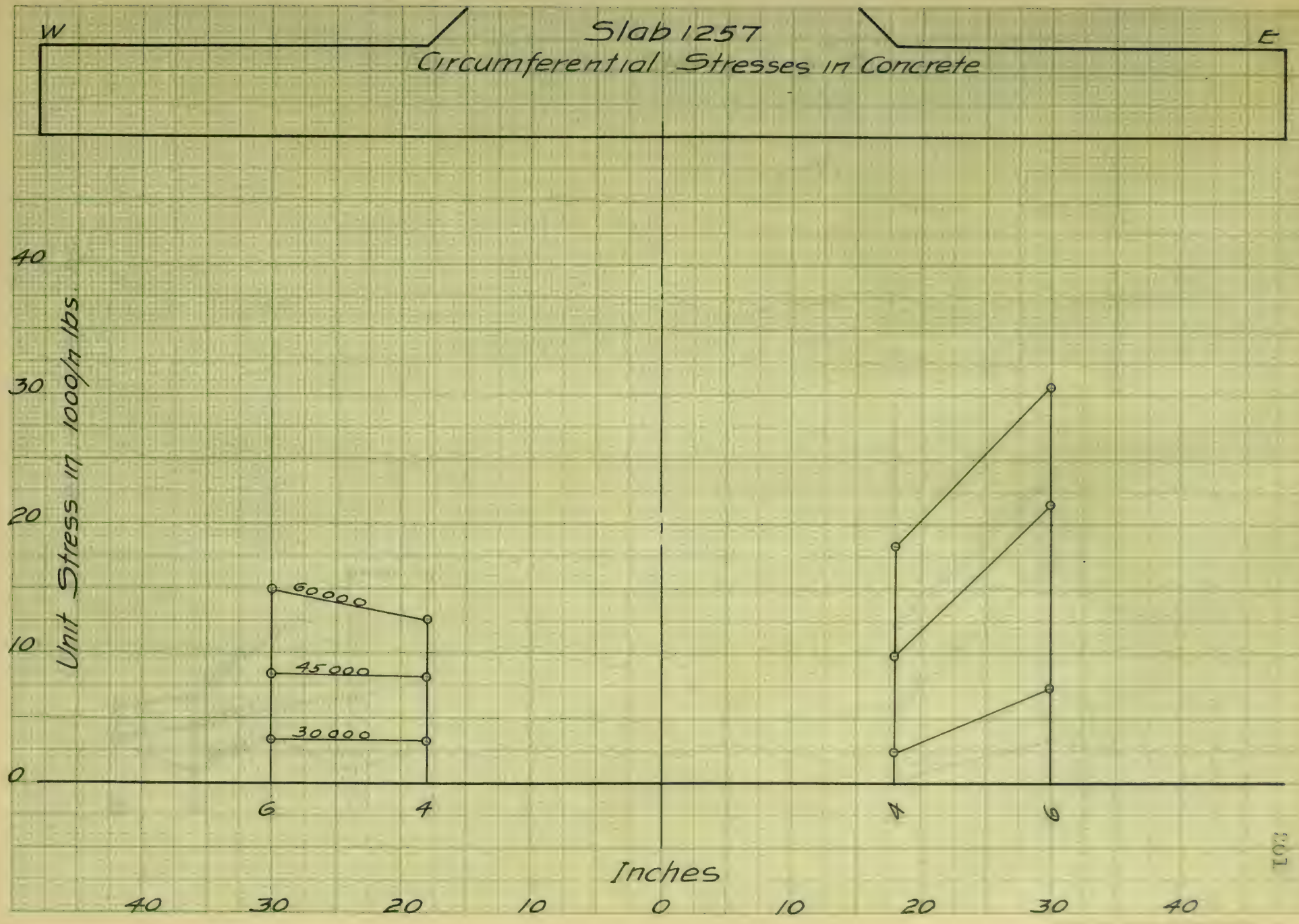

N
Slab 1257
Circumferential Stresses in Steel
S
Unit Stresses in 1000 lbs.
40
30
20
10
0
60000
45000
30000
6
5
4
3
2
1
4
6
Inches
40
30
20
10
0
10
20
30
40

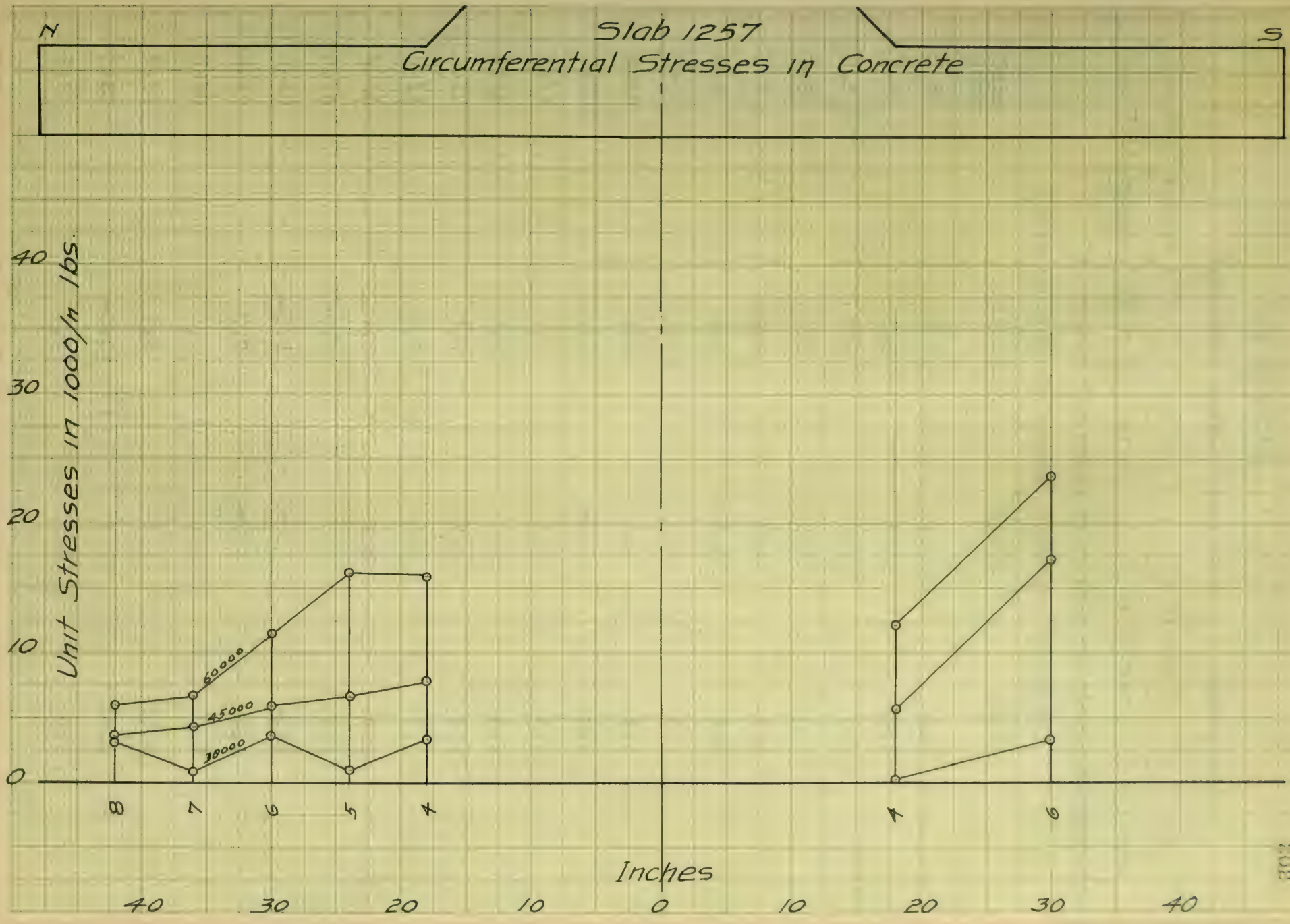


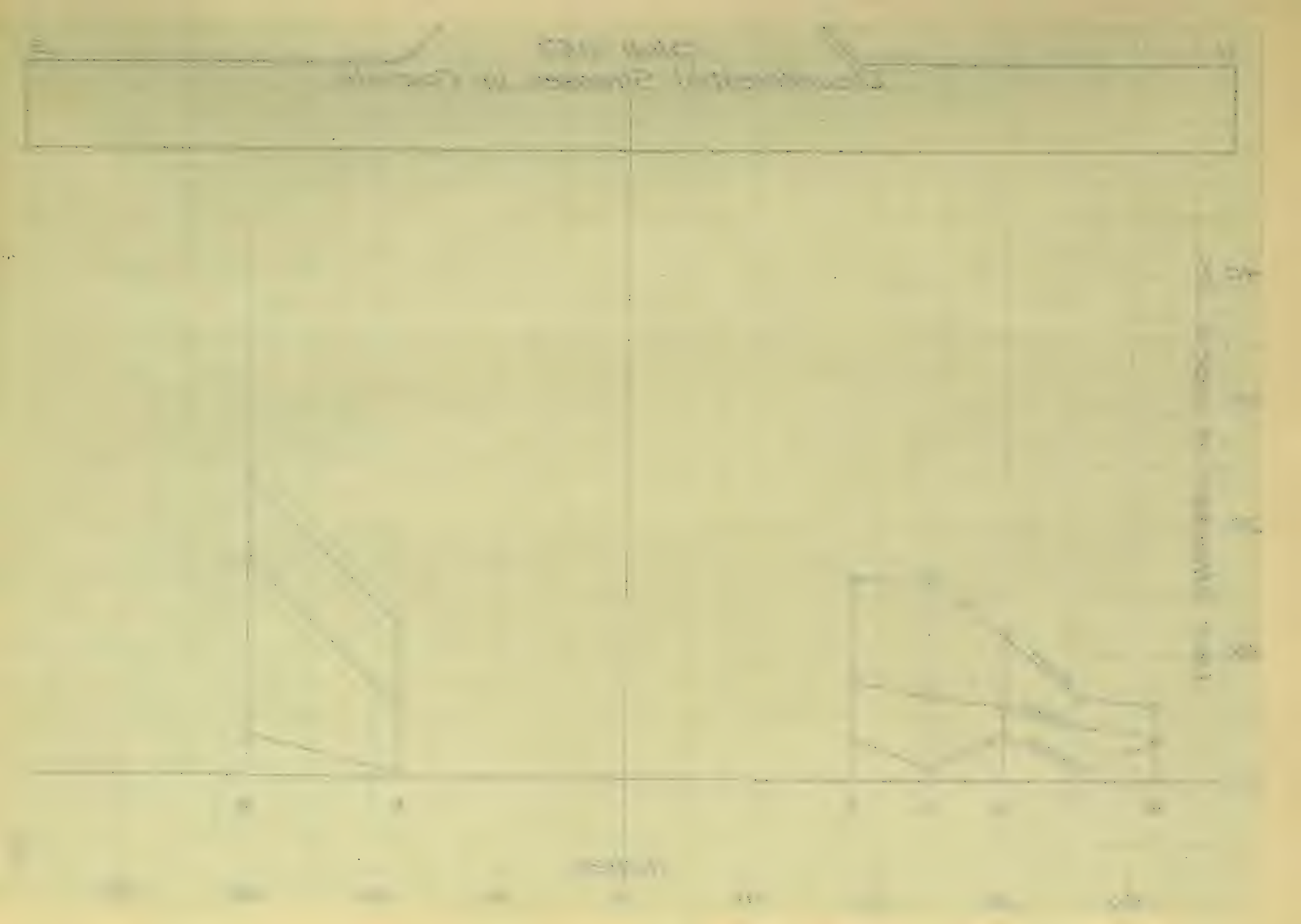

W
Slab 1257
Circumferential Stresses in Steel
E
Unit Stresses in 1000 lbs.
40
30
20
10
0
60000
45000
30000
6
4
4
6
Inches
40
30
20
10
0
10
20
30
40


N
Slab 1257
Radial Stresses in Concrete
S
40
30
20
10
0
Unit Stresses in 1000/# lbs.
60000
45000
30000
G
F
E
D
Inches
40
30
20
10
0
10
20
30
40




W
Slab 1257
Circumferential Stresses in Concrete
E
40
30
20
10
0
Unit Stress in 1000/n lbs.
60000
45000
30000
6
4
4
6
Inches
40
30
20
10
0
10
20
30
40


N
Slab 1257
Circumferential Stresses in Concrete
S
Unit Stresses in 1000/in lbs.
40
30
20
10
0
60000
45000
30000
8
7
6
5
4
4
6
Inches
40
30
20
10
0
10
20
30
40



LOG OF TESTS.

TABULATED LOAD-STRESS DATA SLAB #[illegible]

One Unit equals 1000 lb. per sq. in. Unit Stress in the Steel.

One Unit equals 1000/n lb. per sq. in. Unit Stress in Concrete.

"n" equals the ratio of moduli of steel to concrete.

Loads on Slab in Pounds--Concrete Stresses.

Gage line	15000	30000	45000
N-3	0.8	3.6	10.5
N-4	1.6	3.4	10.5
N-5	0.6	3.4	10.3
N-6	1.0	3.2	8.8
N-7	-0.4	3.9	9.2
N-8	0.6	3.0	7.4
N-9	0.9	3.6	8.1
N-10	0.4	1.1	3.0
N-10A	-0.3	-0.3	2.2
N-11	1.2	3.1	3.8
N-12	0.9	2.3	5.9
N-13	0.4	2.0	9.4
N-14	0.5	3.2	7.0
N 15	0.6	1.5	7.0
N-16	-0.1	1.3	2.7
N-18	-0.4	-0.3	-1.0
N-19	0.7	-1.1	0.4
N-20	1.1	0.8	7.7
N-21	1.3	3.4	10.4
N-22	-0.2	3.0	14.4
N-27	1.2	2.5	4.9

SLAB # [illegible] [illegible].

Load on Slab in Pounds.

Gage line	15000	30000	45000
N-28	-0.7	0.[illegible]	2.3
N-29	-1.5	-1.5	-1.9
N-B	3.6	4.4	5.0
N-C	-0.7	0.5	-0.9
N-D	0.3	-1.1	-1.7
N-E	-0.6	-1.2	-2.0
E-4	0.9	4.4	11.9
E-8	2.8	4.9	10.7
E-10	0.5	2.2	7.5
E-B	1.1	4.3	14.8
E-C	0.9	0.4	1.3
E-D	-1.1	-0.3	-0.4
E-E	-0.6	-1.5	-1.0
E-F	-0.5	-1.0	-0.8
S-4	0.2	4.9	11.3
S-6	0.0	3.5	11.0
S-8	-0.2	2.3	8.5
S-10	1.0	3.5	8.3
S-C	1.0	2.2	2.5
S-D	0.2	0.3	0.8
S-E	-0.5	-0.5	-0.3
S-F	0.9	-1.2	-1.8
W-4	2.1	4.4	10.7
W-6	-0.5	1.2	3.8
W-8	-0.1	1.4	7.5

SLAB # [illegible] CONCRETE STRESSES.

Load on Tab in pounds.

Gage line	15000	30000	45000
W-10	1.1	1.8	5.5
W-F	1.9	7.0	16.5
W-C	-0.1	2.0	0.5
W-D	0.5	0.3	-2.7
W-E	0.8	-0.8	-3.3
W-F	-0.7	-0.1	-4.7
NE-M	0.9	6.2	16.2
NE-N	0.9	3.9	11.6
NE-X	1.9	3.5	6.9
NE-Y	-1.1	0.2	3.6
SE-M	-0.1	3.0	6.7
SE-N	0.7	5.1	13.3
SE-X	-2.3	-2.5	-0.5
SE-Y	0.0	2.0	6.2
SW-N	1.5	6.3	14.9
SW-X	-0.2	1.3	3.2
SW-Y	-1.6	3.1	6.8
NW-M	0.1	3.0	5.7
NW-N	-0.7	3.9	11.0
NW-X	-0.3	0.7	3.1
NW-Y	-0.3	0.9	2.2
N-B1	2.1	5.9	11.1
N-B2	3.3	8.1	13.5
N-B3	2.1	2.7	6.0
NW-M1	3.0	8.7	23.4

CLASS A 1251 CONCRETE STRESS.

Load on dial in pounds.

Gage line	15000	30000	45000
NW-M2	3.3	8.5	12.0
NW-M3	0.9	1.5	3.1
NW-N1	2.4	12.9	30.7
NW-N2	4.8	7.8	27.0
NW-N3	3.6	10.8	16.8

SLAB # 1871 STEEL STRINGER.

Load on Slab in Pounds.

Gage line	15000	30000	45000
N-1	-1.2	0.7	14.0
N-2	0.9	5.7	17.6
N-3	0.6	6.0	23.1
N-4	0.2	7.6	27.1
N-5	-2/3	6.4	18.1
N-6	0.7	7.5	21.2
N-7	-1.0	4.9	16.8
N-8	1.3	7.0	17.4
N-9	-0.8	3.3	14.4
N-10	1.4	6.6	14.3
N-12	1.6	5.4	12.3
N-13	-1.4	3.9	13.2
N-14	-1.6	9.0	17.0
N-15	-0.2	2.0	12.9
N-16	0.7	1.2	9.0
N-17	2.3	-0.8	0.7
N-18	0.4	-1.2	7.2
N-19	-0.4	0.4	15.8
N-20	4.0	3.7	21.8
N-21	1.2	7.0	33.4
N-22	1.2	7.8	26.4
N-23	1.1	7.0	28.7
N-24	0.2	6.1	24.4
N-25	5.7	5.8	23.9
N-26	1.0	-0.4	10.5

SLAB / [illegible] STEEL STRESSES.

Load on Slab in Pounds.

Gage line	15000	30000	45000
N-27	-0.9	-3.9	-1.6
N-28	-1.1	-1.5	-2.5
N-Z	-1.1	-[illegible]	7.6
N-B	2.5	7.3	22.3
N-C	1.3	3/6	16.3
N-D	-0.2	2.1	14.5
N-E	[illegible].7	0.9	11.9
N-F	-2.6	-1.3	6.8
E-3	0.2	5.0	24.8
E-4	0.6	6.1	[illegible].8
E-6	-0.4	2.4	17.6
E-8	1.7	[illegible].9	16.3
E-10	2.1	4.9	16.3
E-Z	1.5	1.5	14.2
E-A	0.2	9.5	28.6
E-B	-0.4	[illegible].3	[illegible].3
E-C	-[illegible].4	8.0	21.8
E-D	-1.7	-[illegible].4	11.4
E-E	1.3	1.[illegible]	18.8
E-F	-1.4	-1.6	-4.6
S-3	4.[illegible]	1[illegible].[illegible]	29.2
S-4	0.8	10.2	27.8
S-6	0.6	[illegible].2	20.7
S-8	0.1	[illegible].2	[illegible].[illegible]
S-10	[illegible].2	[illegible].0	17.5

SLAB [illegible] STEEL STRESSES.

Load on Slab in Pounds.

Gage line	15000	30000	45000
S-A	1.1	1.2	[illegible]
S-B	1.1	[illegible]	20.0
S-C	4.4	9.2	16.1
S-D	[illegible]	6.1	18.0
S-E	0.5	1.7	15.0
S-F	−[illegible].2	[illegible]	.9.5
W-3	0.6	6,2	[illegible]
W-4	1.7	7.2	27.8
W-6	0.8	6.1	19.1
W-8	1.7	5.0	17.1
W-10	2.1	4.5	14.6
W-A	2.9	6.7	[illegible]
W-B	4.0	15.4	42.0
W-C	−0.2	6.4	27.2
W-D	0.3	2.3	10.1
W-E	0.1	0.3	0.8
W-F	−0.7	−0.6	1.0
NE-M	1.7	15.7	24.3
NE-N	[illegible]	[illegible]	[illegible]
NE-O	1.6	[illegible]	30.0
NE-P	1.7	10.2	31.9
NE-X	0.7	0.1	13.0
NE-Y	1.8	[illegible]	17.0
SE-M	−0.2	1.7	15.2
SE-N	−[illegible]	5.4	21.7

GLAS # 1251 STEEL STRINGERS.

Load on Flat in Pounds.

Cage line	15000	30000	45000
SE-O	0.6	[illegible]	29.4
SE-P	-0.5	[illegible]	[illegible]
SW-M	[illegible]	5.4	[illegible]
SW-N	0.8	[illegible]	20.5
SW-O	[illegible]	10.9	19.7
SW-P	[illegible]	7.5	22.4
SW-X	-0.3	3.9	17.2
SW-Y	0.6	[illegible]	17.2
NW-M	1.4	8.0	[illegible]
NW-O	[illegible]	11.7	23.1
NW-P	1.8	7.4	[illegible]
NW-X	[illegible]	1.6	22.8
NW-Y	[illegible]	1.7	[illegible]

TABULATED DEFLECTION DATA SLAB [illegible]

One Unit equals [illegible] lb. per sq. in. Unit Stress in the Steel.

One Unit equals 1000/n lb. per sq. in Unit [illegible] in Concrete.

"n" equals the ratio of moduli of steel to concrete.

Load on Slab in Pounds--Steel Stresses.

Gage line	15000	[illegible]	45000	60000	75000
N-1	1.3	-0.7	10.2	[illegible]	29.8
N-2	0.0	0.3	[illegible]	21.0	32.0
N-3	[illegible]	0.0	16.4	[illegible]	39.6
N-4	-1.6	-0.1	14.7	26.7	41.4
N-5	0.5	0.2	18.6	[illegible]	[illegible]
N-6	-1.4	2.8	20.5	[illegible]	66.8
N-7	-1.8	1.0	[illegible]	37.6	[illegible]
N-8	-1.2	5.2	26.0	32.4	[illegible]
N-9	-1.8	1.7	[illegible]	[illegible]	51.5
N-10	-1.4	1.5	[illegible]	30.4	44.0
N-11	-0.5	4.5	[illegible]	[illegible]	41.9
N-12	-0.8	1.7	14.9	25.7	45.3
N-14	-5.4	0.6	11.2	[illegible]	[illegible]
N-15	-1.5	-0.3	16.5	[illegible]	[illegible]
N-16	-1.2	-0.1	14.8	21.8	[illegible]
N-17	-4.3	-1.7	[illegible]	21.5	[illegible]
N-18	-4.0	4.3	[illegible]	[illegible]	32.9
N-19	-2.4	3.0	[illegible]	[illegible]	46.4
N-20	-1.0	4.5	[illegible]	[illegible]	[illegible]
N-21	-3.7	3.1	[illegible]	34.2	49.0
N-22	-5.5	[illegible]	20.9	[illegible]	[illegible]

SLAB # [illegible]

Load on Slab in Pounds

Gage Line	15000	30000	[illegible]	60000	75000
N-[illegible]	-5.4	[illegible]	18.1	[illegible]	136.9
N-11	-5.8	-0.5	16.7	39.6	69.0
N-[illegible]	-7.1	[illegible]	[illegible]	[illegible]	[illegible]
N-[illegible]	-7.9	-1.0	19.0	26.9	[illegible]
N-[illegible]	-4.1	-[illegible]	10.1	[illegible]	42.3
N-A	-1.6	1.1	[illegible]	23.7	31.0
N-B	0.8	[illegible]	[illegible]	[illegible]	62.1
N-C	-0.4	[illegible]	25.5	[illegible]	[illegible]
N-D	-1.0	3.1	20.2	27.7	40.1
N-[illegible]	-[illegible]	[illegible]	18.1	26.1	41.0
N-F	-[illegible]	[illegible]	10.7	17.8	31.9
E-7	-2.0	11.6	25.2	37.1	67.2
E-9	-2.3	9.7	22.5	31.6	[illegible]
E-11	0.4	9.0	21.6	[illegible]	[illegible]
E-C	-[illegible]	[illegible]	[illegible]	38.9	41.4
E-D	-1.4	[illegible]	[illegible]	34.[illegible]	41.2
E-E	-1.9	[illegible]	13.0	[illegible]	[illegible]
E-F	[illegible]	[illegible]	6.9	[illegible]	[illegible]
S-7	1.3	[illegible]	[illegible]	[illegible]	[illegible]
S-9	-0.8	[illegible]	[illegible]	[illegible]	[illegible]
S-11	-[illegible]	7.4	[illegible]	[illegible]	96.2
S-C	-0.1	5.2	21.6	[illegible]	[illegible]
S-D	-1.5	[illegible]	17.9	27.4	[illegible]
S-E	-2.4	[illegible]	[illegible]	[illegible]	[illegible]
S-F	-5.0	0.8	[illegible]	15.6	[illegible]

SLAB #1[illegible]---STEEL STRESSES.

Load in Slab in Pounds.

Gage line	15000	30000	45000	60000	75000
N-7	0.0	7.4	[illegible]	[illegible]	57.5
N-9	[illegible]	6.7	[illegible]	30.8	41.4
N-11	[illegible]	[illegible]	24.1	29.7	[illegible]
N-C	[illegible]	[illegible]	[illegible]	40.7	87.8
N-D	0.5	[illegible]	19.5	32.1	37.4
N-E	0.2	-0.1-	[illegible]	[illegible]	22.5
N-F	-1.4	-1.1	7.8	8.4	10.2
NE-M	[illegible]	8.4	[illegible]	[illegible]	[illegible]
NE-N	-1.4	5.4-	[illegible]	27.6	83.6
NE-C	[illegible]	3.0	[illegible]	25.7	[illegible]
NE-F	-0.1	[illegible]	14.6	18.9	[illegible]
CE-M	1.5	4.1	19.2	31.0	72.0
SE-N	-0.5	3.3	16.6	[illegible]	77.3
SE-Φ	0.7	[illegible]	15.1	27.4	74.3
SE-F	-3.7	4.3	12.4	23.9	[illegible]
SE-M	-[illegible]	[illegible]	[illegible]	[illegible]	67.3
SW-N	0.6	7.2	24.0	37.5	76.7
SW-C	-3.5	[illegible]	15.6	[illegible]	45.6
SW-F	-[illegible]	-[illegible]	16.7	[illegible]	43.0
NW-M	-1.4	10.0	26.2	[illegible]	54.8
NW-N	-[illegible]	5.7	22.1	[illegible]	71.7
NW-Φ	[illegible]	6.6	[illegible]	24.6	71.3
NW-F	0.5	[illegible]	16.0	24.7	44.5

SLAB # 1252 CONCRETE STRAINS.

Load on Slab in Pounds

Gage line	15000	30000	45000	60000	75000
N-4	1.9	3.1	5.8	7.2	11.7
N-5	2.0	3.1	7.2	11.2	22.9
N-6	1.5	2.3	10.0	10.4	14.7
N-7	3.1	2.9	-3.0	9.9	20.9
N-9	7.3	-3.2	2.7	8.1	17.4
N-10	5.1	6.6	10.1	10.6	14.6
N-11	2.1	8.1	11.4	14.6	22.5
N-11A	2.7	5.9	9.5	13.9	20.5
N-15	1.6	1.3	4.7	7.1	11.6
N-16	3.4	0.7	4.9	7.4	10.7
N-17	1.3	1.5	2.7	2.3	14.0
N-18A	-0.5	1.0	1.3	2.5	2.7
N-18B	4.1	5.5	6.1	7.2	10.8
N-23	0.4	3.9	5.6	6.9	26.6
N-27A	-1.2	-0.5	-0.6	-0.6	7.4
N-27B	-3.4	-1.5	-2.0	-1.7	-1.6
N-D	2.0	2.2	2.5	3.1	5.5
N-E	0.7	1.4	1.3	1.8	0.4
E-9	1.3	4.3	7.6	11.6	16.6
E-11	0.3	2.4	5.5	8.5	12.8
E-C	0.8	3.3	0.7	2.9	6.1
S-9	3.4	2.3	10.1	11.4	20.1
S-11	0.5	3.2	4.3	6.8	15.1
S-C	0.6	4.1	8.8	12.1	11.1
S-F	0.1	-1.8	-1.8	-0.9	-1.7

SLAB # 1[illegible] CONCRETE [illegible].

Load on Slab in Pounds.

Gage line	15000	30000	45000	60000	75000
W-7	-[illegible]	2.7	4.9	[illegible]	17.9
W-9	0.1	1.2	[illegible]	8.4	16.4
W-C'	[illegible]	[illegible]	11.4	19.1	16.0
W-L	1.7	-2.6	[illegible]	[illegible]	0.4
W-E	-[illegible]	[illegible]	3.1	[illegible]	[illegible]
W-F	0.5	1.7	1.1	1.5	-0.7
NE-M	1.5	[illegible]	9.9	14.2	17.4
NE-N	0.5	4.0	7.9	13.0	30.9
NE-O	0.9	2.4	[illegible]	5.7	[illegible]
NE-P	1.8	2.9	5.1	5.2	11.4
SE-M	1.2	3.0	9.3	17.4	51.0
SW-M	2.7	4.7	10.6	[illegible]	[illegible]
SW-N	1.6	3.8	[illegible]	11.8	20.8
SW-O	-1.2	[illegible]	2.4	5.7	[illegible]
SW-P	1.7	1.5	2.6	3.9	11.1
NW-M	0.6	-[illegible]	0.3	7.3	24.2
NW-N	1.0	1.6	8.4	13.8	21.2
NW-O	0.7	[illegible]	4.0	5.4	[illegible]
NW-P	[illegible]	[illegible]	7.1	9.5	14.5
N-C2	5.7	6.0	7.8	12.6	10.8
N-C3	2.1	-5.7	1.8	0.9	0.9
S-C'1	[illegible]	[illegible]	14.7	31.5	[illegible]
S-C'2	-1.2	2.4	9.9	15.6	20.7
W-C'1	1.5	10.5	26.7	45.0	[illegible]

SLAB # 115d CONCRETE STRESSES.

Load on Slab in Pounds.

Gage line	15000	30000	45000	60000	75000
W-C'2	3.0	11.4	12.3	17.3	23.2
W-C'3	1.5	10.5	13.8	15.6	24.6

TABULATED LOAD-STRESS DATA SLAB #1253

One Unit equals 1000 lb. per sq. in. Unit Stress in the Steel.

One Unit equals 1000/n lb. per sq. in. Unit Stress in Concrete.

"n" equals the ratio of the moduli of the steel to concrete.

Load on Slab in Pounds-Concrete Stresses.

Gage line	15000	30000	45000	60000	75000
N-1	-0.6	0.2	5.8	11.4	18.0
N-2	1.1	2.6	8.2	14.5	22.1
N-3	-0.4	0.7	6.0	10.6	16.9
N-4	-0.2	2.0	3.8	9.1	10.6
N-5	-0.4	0.8	6.0	10.7	15.3
N-6	0.7	1.9	8.2	11.2	14.5
N-7	1.8	3.4	8.2	11.7	16.9
N-8	0.8	1.2	1.8	6.4	9.5
N-9	0.9	1.4	2.5	4.4	7.7
N-10	-0.2	1.7	5.3	7.7	11.6
N-11	0.7	2.9	7.0	9.8	13.9
N-12	0.4	2.3	5.9	14.0	24.1
N-14	0.4	2.5	4.7	8.2	17.7
N-17	-0.2	1.8	5.5	9.5	16.2
N-18	1.1	1.6	-1.5	5.2	6.5
N-19	0.3	2.0	-2.5	2.0	3.0
N-A	1.0	3.6	11.6		
N-B	3.1	4.5	6.1	7.9	10.9
N-C	-0.6	0.5	0.5	1.3	1.2
N-B	0.4	1.6	3.6	2.5	1.2
NE-M	2.1	4.8	14.6	20.1	29.0

SLAB #1353-- CONCRETE STRESSES.

Load on Slab in Pounds.

Gage Line	15000	30000	45000	60000	75000
NE-N	0.9	3.8	10.3	16.1	23.0
NE-O	0.8	5.0	9.0	14.3	21.3
NE-P	1.9	4.5	18.0	20.0	27.5
E-1	-0.9	1.2	7.3	12.5	20.6
E-3	0.9	3.0	8.6	12.7	17.8
E-5	0.9	1.4	5.2	7.1	14.8
E-7	-0.2	0.4	3.3	6.3	9.0
E-A	1.0	3.9	12.4	17.9	26.4
E-B	1.1	2.7	3.5	6.7	7.3
E-C	0.8	1.8	3.3	6.4	5.3
E-D	1.7	1.2	0.7	1.8	1.7
SE-M	0.9	3.5	8.3	13.3	17.3
SE-N	1.2	5.1	12.8	21.0	30.1
SE-O	1.4	4.3	15.8	28.2	43.0
SE-P	1.9	5.1	12.6	19.3	25.6
S-1	-0.3	1.1	4.6	11.8	17.5
S-3	0.9	2.2	4.7	11.3	16.0
S-5	-0.4	0.7	3.5	13.0	22.1
S-7	1.6	1.8	2.7	9.4	15.2
S-A	1.1	1.6	6.8	10.8	20.0
S-B	0.5	1.2	3.2	7.2	2.5
S-C	0.7	0.8	2.0	0.9	0.3
S-D	1.0	0.8-	1.2	1.5	-0.2
SW-M	1.9	4.8	16.0	27.1	38.9
SW-N	-0.2	0.9	9.5	16.7	26.2

Load on Slab in Pounds.

Gage line	15000	30000	45000	60000	75000
SW-O	1.6	3.3	8.6	14.6	21.8
SW-P	1.3	6.3	18.6	32.9	51.[illegible]
W-1	1.0	1.8	7.6	12.4	18.2
W-3	2.3	3.2	10.1	13.0	17.7
W-5	1.5	3.5	9.6	13.7	16.7
W-7	-0.5	0.5	3.1	6.7	8.0
W-A	3.0	6.6	6.6		
W-B	0.7	2.4	5.4	8.1	7.0
W-C	0.4	1.9	3.0	3.6	3.0
W-D	-0.8	1.3	-0.3	0.3	0.2
NW-M	0.8	5.3	16.1	29.3	45.0
NW-N	2.5	2.6	4.9	21.7	35.6
NW-O	1.7	5.2	10.8	19.7	33.8
NW-P	3.2	3.7	14.3	25.5	37.7
A-1	3.3	11.1	26.4	39.0	56.1
A-2	2.7	7.2	9.0	17.4	15.6
A-3	-2.7	0.3	14.1	17.3	10.5
M-1	5.7	8.4	34.2	70.8	72.9
M-2	6.0	9.9	19.2	29.7	31.2
M-3	3.6	3.0	6.3	10.8	12.0
N-1	1.5	15.9	6.6	21.6	45.6
N-2	6.3	12.0	24.9	38.1	46.8
N-3	2.7	4.5	23.1	23.7	37.2
O-1	2.1	0.6	7.8	24.3	54.9
O-2	4.2	7.8	13.2	31.6	33.2

SLAB #[illegible]---CONCRETE STRESSES.

Load on Slab in Pounds.

Gage line	15000	30000	45000	60000	75000
O-3	3.9	5.1	13.2	21.3	28.8
P-1	0.0	9.3	29.4	55.8	87.0
P-2	3.6	7.5	18.0	24.6	25.2
P-3	4.5	5.7	13.2	17.7	18.9

SLAB [illegible] .

Load on Slab in Pounds.

Gage line	15000	30000	45000	60000	75000
N-1	2.4	3.4	15.4	26.4	56.9
N-2	2.7	4.4	15.1-	41.1	50.1
N-3	3.0	5.4	17.0	39.7	55.6
N-4	2.4	3.9	16.0	37.1	57.1
N-5	1.8	3.2	15.5	36.7	48.6
N-6	0.6	3.9	13.8	37.8	42.1
N-9	1.1	0.1	7.6	30.3	40.6
N-10	0.9	0.0	9.4	33.9	48.8
N-11	1.3	2.6	14.0	40.5	53.7
N-12	3.5	4.6	15.4	42.7	55.5
N-13	1.0	2.3	14.9	42.7	62.3
N-14	0.1	5.2	12.6	37.5	70.6
N-15	1.3	5.3	18.5	43.0	56.5
N-16	3.5	8.9	26.6	58.2	68.7
N-17	5.1	10.6	13.0	23.4	41.2
N-18	-2.1	0.9	6.0	16.7	29.8
N-(-1)	4.7	4.5	11.4	28.9	35.1
N-(-2)	3.8	2.8	7.0	18.4	21.2
N-(-3)	2.7	2.0	5.8	7.4	14.3
N-(-4)	-0,4	-1.2	2.8-	1.1	3.2
N-A	5.0	8.2	17.8	26.9	36.0
B-B	2.6	3.6	14.1	27.4	31.6
N-C	3.6	3.3	10.6	22.3	26.9
N-D	2.5	2.9	7.7	16.9	26.0
N-a	4.7	6.0	6.0	25.5	35.9

SLAB FILLS---STEEL GIRDERS.

Load on Slab in Pounds.

Gage line	15000	30000	45000	60000	75000
N-b	5.1	8.5	4.0	9.8	[illegible]
N-c	4.7	1.9	0.6	4.1	5.1
NE-M	3.8	4.8	19.8	[illegible]	[illegible]
NE-N	3.9	4.0	17.9	31.0	[illegible]
NE-O	3.7	4.3	17.5	[illegible]	45.6
NE-P	3.3	3.7	18.8	[illegible]	52.6
E-1	4.7	5.2	18.9	[illegible]	57.2
E-3	3.3	3.0	17.2	[illegible]	42.3
E-5	4.8	2.7	17.8	26.6	37.2
E-A	4.1	5.4	19.4	[illegible]	[illegible]
E-B	4.6	4.2	12.1	[illegible]	34.9
E-C	2.0	1.4	4.0	14.5	[illegible]
E-D	0.8	0.7	0.8	[illegible]	[illegible]
SE-M	3.6	6.9	20.4	[illegible]	44.7
SE-N	2.6	4.4	18.6	[illegible]	[illegible]
SE-O	-1.4	5.7	20.9	[illegible]	[illegible]
SE-P	[illegible]	[illegible]	19.1	[illegible]	[illegible]
S-1	2.3	[illegible]	[illegible]	[illegible]	[illegible]
S-3	2.4	3.9	9.9	24.6	41.3
S-5	2.4	2.9	8.9	[illegible]	[illegible]
S-A	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
S-B	2.8	3.0	11.6	23.1	[illegible]
S-C	2.8	2.6	[illegible]	[illegible]	28.0
S-D	-1.0	0.3	-2.4	9.6	25.2
SW-M	2.6	5.7	19.5	[illegible]	50.9

CLASS [illegible]---STEEL ATTACHED.

Load on Slab in Pounds.

Gage line	15000	30000	45000	60000	75000
SW-N	3.7	5.8	17.8	35.2	[illegible]
S[illegible]-O	3.0	5.8	16.2	29.2	47.0
SW-1	1.6	6.2	23.8	50.1	79.9
W-1	1.9	7.8	15.7	26.0	41.5
W-3	5.6	9.6	16.7	31.0	49.9
W-5	4.5	7.4	20.6	33.1	55.8
W-A	3.7	6.3	18.2	30.9	51.9
W-B	1.2	5.6	12.9	19.2	71.1
W-C	4.5	8.3	19.6	47.9	71.7
W-D	3.3	-1.3	5.7	9.8	17.1
NW-M	4.1	5.9	23.1	37.8	50.7
NW-N	3.2	4.9	19.9	32.6	71.5
NW-O	3.2	5.2	18.0	27.2	42.5
NW-P	4.1	6.1	24.7	39.5	113.2

TABULATED [illegible] DATA [illegible]

One Unit equals 1000 lb. per sq. in. Unit Stress in the Steel.

One Unit equals 1000/n lb. per sq. in. Unit Stress in Concrete.

"n" equals the ratio of the moduli of steel to concrete.

Load on Slab in Pounds--Steel Stresses.

Gage Line	30000	60000	80000	100000
N-1	0.1	0.1	[illegible]	[illegible]
N-2	1.9	0.8	[illegible]	[illegible]
N-3	1.1	[illegible]	[illegible]	[illegible]
N-4	1.7	0.9	1.4	[illegible]
N-5	[illegible]	[illegible]	[illegible]	[illegible]
N-6	2.6	[illegible]	[illegible]	[illegible]
N-7	[illegible]	[illegible]	[illegible]	[illegible]
N-8	2.0	7.7	[illegible]	43.1
N-9	1.1	[illegible]	[illegible]	36.4
N-10	1.6	10.6	[illegible]	[illegible]
N-11	[illegible]	[illegible]	[illegible]	[illegible]
N-12	0.6	1.1	[illegible]	[illegible]
N-13	1.9	6.3	[illegible]	[illegible]
N-14	1.7	5.8	[illegible]	[illegible]
N-15	1.0	10.1	[illegible]	[illegible]
N-16	[illegible]	[illegible]	[illegible]	[illegible]
N-17	[illegible]	[illegible]	[illegible]	[illegible]
N-18	[illegible]	[illegible]	[illegible]	[illegible]
N-19	[illegible]	[illegible]	[illegible]	[illegible]
N-20	[illegible]	[illegible]	[illegible]	[illegible]
N-21	0.7	0.9	[illegible]	[illegible]

[illegible] 1951 [illegible].

Load on Slab in Pounds.

Gage line	30000	60000	80000	100000
N-a	-0.2	[illegible]	1.6	[illegible]
N-b	0.7	1.1	[illegible]	18.1
N-c	[illegible]	[illegible]	[illegible]	[illegible]
N-d	4.8	21.5	[illegible]	[illegible]
E-A	3.0	15.1	[illegible]	[illegible]
E-B	1.4	[illegible]	11.8	14.4
N-C	[illegible]	1.6	[illegible]	[illegible]
E-6	[illegible]	[illegible]	[illegible]	35.0
E-8	4.0	[illegible]	[illegible]	[illegible]
E-10	5.4	13.7	[illegible]	[illegible]
E-B	1.5	[illegible]	[illegible]	21.0
E-A	[illegible]	16.5	[illegible]	65.0
S-6	1.8	6.7	[illegible]	38.5
S-7	[illegible]	[illegible]	[illegible]	56.2
S-8	[illegible]	[illegible]	23.8	52.2
S-9	[illegible]	[illegible]	[illegible]	38.5
S-10	1.3	[illegible]	[illegible]	38.0
S-11	2.4	[illegible]	[illegible]	31.8
S-A	4.4	[illegible]	[illegible]	[illegible]
S-B	[illegible]	[illegible]	22.9-	51.7
W-6	2.1	2.6	[illegible]	[illegible]
W-8	[illegible]	9.8	[illegible]	37.0
W-10	1.6	[illegible]	[illegible]	61.0
W-A	1.4	11.1-	28.0	39.9
W-B	0.4	1.7	[illegible]	14.9

SLAB # 1254 STEEL THICKNESS.

Load on Slab in Pounds.

Gage Line	[illegible]0	60000	[illegible]0	100000
NE-M	1.6	8.7	[illegible]	[illegible]
NE-N	1.7	[illegible]	[illegible]	[illegible]
NE-O	1.8	[illegible]	13.9	22.4
SE-M	[illegible]	[illegible]	22.1	[illegible]
SE-N	1.7	14.2	[illegible]	[illegible]
SE-O	4.3	[illegible]	17.0	[illegible]
SW-P	[illegible]	[illegible]	9.9	[illegible]
SW-M	1.8	[illegible]	[illegible]	[illegible]
SW-N	1.9	12.4	[illegible]	[illegible]
SW-O	1.6	[illegible]	[illegible]	[illegible]
SW-P	1.6	6.3	[illegible]	[illegible]
NW-M	[illegible]	11.9	[illegible]	[illegible]
NW-N	[illegible]	[illegible]	[illegible]	[illegible]
NW-O	1.4	8.0	16.1	24.3

CLAP / 1954 [illegible] ESSAIS.

[illegible] en Clab la Prenda.

Cage Lire	30000	60000	80000	100000
N-7	[illegible]	[illegible]	4.9	[illegible]
N-8	[illegible]	[illegible]	9.2	14.7
N-9	1.5	[illegible]	12.0	17.7
N-10	1.0	7.2	[illegible]	16.7
N-11	1.4	[illegible]	11.6	15.1
N-11A	0.8	[illegible]	[illegible]	[illegible]
N-11B	[illegible]	0.7	2.5	4.2
N-12	0.6	[illegible]	[illegible]	[illegible]
N-13	[illegible]	[illegible]	8.0	9.8
N-14	0.5	[illegible]	9.2	12.6
N-15	0.8	5.7	9.4	13.4
N-16	1.7	4.6	7.7	12.9
N-16'	[illegible]	4.1	8.2	12.9
N-17	1.1	[illegible]	4.4	7.7
N-20	1.8	5.7	9.8-	10.7
N-21	[illegible]	[illegible]	2.2	[illegible]
N-22	[illegible]	[illegible]	4.6	11.5
N-A-	2.4	[illegible]	[illegible]	15.2
N-B	1.4	[illegible]	[illegible]	3.7
N-C	1.6	0.8	—0.2	—1.2
E-8	1.4	6.1	9.1	[illegible]
E-10	0.5	4.6	[illegible]	8.1
E-11A	2.7	4.1	4.9	9.0
E-A	[illegible]	7.4	14.9	[illegible]

PLATE # 1164 CONCRETE STRESSES.

Load on Slab in Pounds.

Gage line	40000	60000	80000	100000
S-5	1.7	2.2	7.1	7.3
S-6	0.4	1.3	3.1	4.7
S-7	2.1	1.7	4.7	11.7
S-8	2.7	5.1	12.7	21.1
S-9	0.8	0.8	8.1	17.2
S-10	1.5	4.9	7.7	11.0
S-11	0.9	4.0	7.5	11.1
S-11A	3.4	5.1	9.9	17.1
S-A	7.4	11.1	17.1	18.0
S-B	1.9	8.7	2.1	4.9
S-C	0.8	1.1	1.3	1.7
J-8	3.8	7.1	9.9	17.7
J-10	3.1	7.2	7.6	12.1
J-11A	3.5	7.6	9.7	18.1
J-A	3.2	4.1	11.7	12.1
J-B	-0.5	1.7	3.1	4.6
W-C	1.7	1.5	1.6	2.5
NE-C	2.7	4.0	4.7	13.3
SE-M	6.5	10.3	17.2	11.0
SE-H	3.4	.2	6.5	17.3
SE-O	2.7	5.3	8.3	10.7
SE-P	2.6-	3.3	7.4	10.1
SW-H	-0.7	1.3	7.1	17.3
NW-M	3.1	5.7	12.4	17.4
NW-H	2,7	7.2	11.7	14.9

SLAB # CONCRETE STRESSES.

Load on Slab in Pounds.

Gage line	50000	60000	[illegible]	[illegible]
N.-C	1.1	6.3	7.[illegible]	1.[illegible]
N-A1	5.1	11.2	14.3	24.1
N-A2	-3.[illegible]	12.[illegible]	1[illegible].0	27.6
N-A3	2.1	6.0	17.3	11.1
E-A1	9.6	27.0	41.1	67.2
E-A2	1.8	13.5	20.[illegible]	24.9
E-A3	1.3	12.0	11.7	14.7
S-A1	0.3	37.4	52.6	72.6
S-A2	7.2	21.9	21.0	37.1
S-A3	11.7	15.3	19.2	20.1
W-A1	-2.4	0.0	3.9	3.3
W-A2	-1.8	11.1	11.7	17.1
W-A3	2.1	9.9	12.0	19.5

TABULATED LOAD-STRESS DATA SLAB #1256.

One Unit equals 1000 lb.per sq. in. Unit-Stress in the Steel.

One Unit equals 1000/n lb. per sq. in. Unit-Stress in Concrete.

"n" equals the ratio of the modulii of steel and concrete.

Load on Slab in Pounds-- Concrete Stresses.

Gage line	30,000	45,000	60,000	75,000
N-6	-00.6	01.3	07.4	15.2
N-8	-00.3	01.6	07.9	14.4
N-9	01.6	05.1	10.5	16.8
N-12	00.6	08.0	08.9	14.2
N-13	-01.2	02.3	08.4	15.1
N-15	00.1	01.7	05.2	09.4
N-B	01.6	01.7	03.1	04.1
N-C	02.0	-05.2	-01.0	-01.8
N-D	00.9	-02.0	-00.2	-00.7
E-6	00.9	02.3	07.3	12.1
E-8	00.2	06.6	11.9	17.3
E-9	02.0	07.3	11.9	16.8
E-12	02.0	08.4	12.8	16.0
E-13	00.7	05.5	10.7	15.9
E-15	-02.5	-02.1	02.4	03.0
E-C	-01.1	-01.7	-00.6	-01.3
E-D	-01.2	-03.0	-03.3	-05.1
S-6	-00.6	02.2	06.5	10.0
S-8	-00.1	05.7	10.6	17.8
S-9		05.2	09.2	13.0
S-12	02.8	06.8	11.5	16.6

Loads on Slab in Pounds--Concrete [illegible].

Gage Line	30,000	45,000	60,000	75,000
S-13	00.4	04.5	09.6	12.7
S-15	-00.1	[illegible]4.7	08.2	12.9
S-16	-01.1	-00.6	-00.1	[illegible]3.4
S-17	-01.0	01.5	[illegible]4.[illegible]	08.0
S-18	-00.9	00.0	05.1	06.2
S-19	02.0	03.4	08.5	11.4
S-20	02.3	05.6	07.3	09.3
S-21		-02.3	-03.3	-02.9
S-22	-00.1	-03.3	05.9	08.7
S-23	00.3	00.7	04.1	[illegible]6.9
S-24	-01.8	-00.9	-00.2	[illegible]0.5
S-25	-01.1	-00.9	00.5	01.9
S-26	-01.2	05.1	06.4	07.8
S-27	02.4	07.3	10.0	17.4
S-28	03.2	07.5	10.8	13.9
S-29	01.3	[illegible]6.3	11.4	[illegible]0.5
S-31	02.4	06.5	10.1	14.4
S-32	06.0	08.3	10.3	14.9
S-33	-03.0	-00.7	01.3	04.2
S-34	00.1	02.0	00.9	03.1
S-35	-02.0	-01.9	00.3	00.6
S-A	06.0	13.5	22.1	30.9
S-B	-00.5	00.5	01.4	01.8
S-C	00.8	03.6	00.8	01.5
W-6	-00.9	00.1	03.7	09.6
W-10	02.2	05.0	08.3	14.6

Slab #1555.

Loads on Slab in Pounds--Concrete Stresses.

Core line	30,000	45,000	60,000	75,000
W-11	02.5	06.6	09.2	15.6
W-12	01.2	07.0	10.4	11.0
W-13	04.3	11.1	14.4	19.1
W-14	02.8	10.2	13.7	20.3
W-15	01.5	12.9	11.2	17.0
W-A	02.1	07.0	11.2	14.0
W-A'	01.2	02.4	04.4	04.2
W-B	-01.6	-00.8	-02.5	-02.5
W-C	00.1	00.9	00.9	00.1
W-D	00.4	-02.7	-02,2	00.5
NE-M	03.7	08.5	10.7	12.5
NE-N	03.2	07.7	13.9	19.0
NE-P	01.7	01.5	05.6	05.7
NE-R	-00.6	01.2	03.3	05.3
NE-S	-01.4	01.1	03.6	06.6
NE-T	00.2	03.9	05.9	11.2
SE-M	06.4	16.3	28.9	43.2
SE-O	08.4	08.6	17.3	26.9
SE-P	02.2	09.8	15.7	21.3
SE-Q	01.2	02.6	03.3	05.5
SE-R	01.4	01.4	05.0	05.6
SE-S	01.0	04.7	08.0	13.1
SE-T	01.2	03.6	06.1	09.5
SW-M	04.0	09.3	12.5	16.7
SW-N	06.5	09.4	12.4	19.6

SLAB # 1755---CONCRETE STRESSES.

Loads on Slab in Pounds.

Gage line	30,000	45,000	60,000	75,000
SW-P	1.8	5.4	13.5	27.5
SW-T	2.5	1.3	5.2	9.3
NW-M	2.7	9.7	13.6	14.6
NW-P	2.9	8.3	14.0	19.3
NW-R	-0.3	1.0	7.0	8.3
N-A1	6.6	25.8	30.9	40.5
N-A2	3.0	17.4	16.8	20.1
E-A1	0.4	14.7	22.8	32.7
E-A2	9.9	17.1	16.5	21.0
E-A3	8.4	12.9	14.4	12.3
E-A4	3.0	5.7	6.3	0.6
S-A1	-4.1	-10.6		

SLAB [illegible]---STEEL STRESSES.

Loads on Slab in Pounds.

Curve line	30,000	45,000	60,000	[illegible]
N-6	8.7	[illegible]	[illegible]	[illegible]
N-8	9.6	[illegible]	[illegible]	[illegible]
N-[illegible]	8.6	[illegible]	[illegible]	41.6
N-12	8.9	[illegible]	[illegible]	[illegible]
N/13	7.2	[illegible]	[illegible]	[illegible]
N-15	8.6	[illegible]	26.9	[illegible]
N-A	8.5	16.5	[illegible]	[illegible]
N-B	8.7	[illegible]	[illegible]	[illegible]
N-C	-[illegible]	[illegible]	[illegible]	[illegible]
N-D	-2.1	5.9	[illegible]	[illegible]
E-6			[illegible]	[illegible]
E-8	[illegible]	[illegible]	[illegible]	41.1
E-9	[illegible]	[illegible]	[illegible]	[illegible]
E-12	[illegible]	[illegible]	[illegible]	[illegible]
E-13	[illegible]	[illegible]	[illegible]	[illegible]
E-A	[illegible]	[illegible]	[illegible]	[illegible]
E-B	-[illegible]	[illegible]	[illegible]	[illegible]
E-C	[illegible]	[illegible]	16.4	[illegible]
S-6	[illegible]	[illegible]	[illegible]	43.9
S-8	[illegible]	[illegible]	[illegible]	[illegible]
S-9	[illegible]	[illegible]	[illegible]	[illegible]
S-12	[illegible]	14.6	24.2	39.7
S-A	7.1	[illegible]	[illegible]	[illegible]
S-B	1.4	11.4	21.6	24.4
S-C	-1.5	6.4	15.5	19.7

[illegible] / 1915---STEEL [illegible].

Tensile [illegible] in Pounds,

Cage line	[illegible],000	45,000	60,000	[illegible],000
S-D	[illegible]	3.7	[illegible]	[illegible]
S-27	[illegible]	[illegible]	17.1	[illegible]
S-28	1.7	[illegible]	[illegible]	33.4
S-29	4.1	14.7	[illegible]	[illegible]
S-30	0.1	11.7	22.8	37.4
S-31	5.1	15.7	[illegible]	[illegible]
S-32	1.4	8.0	[illegible]	[illegible]
S-33	[illegible]	[illegible]	[illegible]	[illegible]
S-34	[illegible]	3.3	[illegible]	[illegible]
S-35	-2.1	[illegible]	1.4	7.2
W-1	0.7	[illegible]	[illegible]	[illegible]
W-2	-1.9	2.8	0.4	1.4
W-3	[illegible]	[illegible]	4.5	[illegible]
W-5	-0.1	[illegible]	[illegible]	[illegible]
W-6	0.0	[illegible]	25.7	[illegible]
W-7	[illegible]	17.5	[illegible]	45.7
W-8	[illegible]	15.5	[illegible]	[illegible]
W-9	3.4	[illegible]	[illegible]	[illegible]
W-10	4.7	15.5	[illegible]	[illegible]
W-11	0.7	[illegible]	22.7	[illegible]
W-12	[illegible]	20.8	[illegible]	[illegible]
W-13	[illegible]	12.4	24.4	[illegible]
W-14	[illegible]	[illegible]	[illegible]	[illegible]
W-15	5.0	[illegible]	[illegible]	[illegible]
W-a	1.2	4.5	6.1	7.7

[illegible] -- [illegible],

Loads on Slab in Pounds.

Cure line	30,000	45,000	60,000	[illegible]
W-b	1.8	[illegible]	[illegible]	[illegible]
W-c	7.6	20.8	36.0	46.6
W-A	5.8	[illegible]	29.2	37.2
W-F	2.7	7.2	[illegible]	22.6
W-D	1.0	4.1	4.0	[illegible]
NE-M	5.0	[illegible]	[illegible]	[illegible]
NE-N	2.1	[illegible]	[illegible]	[illegible]
NE-O	6.4	[illegible]	[illegible]	[illegible]
NE-P	4.7	[illegible]	[illegible]	[illegible]
NE-Q	[illegible]	[illegible]	[illegible]	[illegible]
NE-S	5.1	[illegible]	[illegible]	[illegible]
SE-M	7.5	[illegible]	[illegible]	[illegible]
SE-N	[illegible]	[illegible]	[illegible]	[illegible]
SE-O	[illegible]	[illegible]	[illegible]	[illegible]
SE-P	[illegible]	[illegible]	[illegible]	[illegible]
SE-Q	[illegible]	[illegible]	[illegible]	[illegible]
SE-R	1.6	3.4	9.8	[illegible]
SE-S	3.4	[illegible]	[illegible]	[illegible]
SW-M/	[illegible]	[illegible]	[illegible]	[illegible]
SW-N	[illegible]	[illegible]	[illegible]	[illegible]
SW-O	[illegible]	[illegible]	[illegible]	[illegible]
SW-P	[illegible]	[illegible]	[illegible]	[illegible]
NW-M	[illegible]	[illegible]	[illegible]	[illegible]
NW-N	[illegible]	[illegible]	[illegible]	[illegible]
NW-O	[illegible]	[illegible]	[illegible]	[illegible]

TABLE [illegible]— [illegible],

Loads on disk in pounds.

Gage line	30,000	45,000	60,000	75,000
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

TABULATED LOAD-STRESS DATA. [illegible]

One Unit equals 1000 lb. per sq. in., Unit-Stress in the Steel.

One Unit equals 1000/n lb. per sq. in., Unit Stress in Concrete.

"n" equals the ratio of the moduli of Steel and concrete.

Load on Slab in Pounds-- Concrete Stresses.

Gage Line	20,000	45,000	60,000	80,000
N-8	4.5	8.4	17.2	27.0
N-9	3.5	5.6	13.7	21.5
N-12	2.8	6.4	11.7	18.3
N-13	5.9	7.2	10.5	17.4
N-15	3.7	7.3	13.1	18.1
N-A	5.0	13.7	23.3	34.2
N-B	-3.1	0.8	0.7	-1.2
N-C	0.4	-0.3	-1.2	-4.2
N-D	1.2	0,1	-0.7	-2.2
D-6	5.8	[illegible]	[illegible]	[illegible]
E-8	6.6	11.1	19.6	29.8
E-9	5.8	11.0	16.2	26.5
E-12	2.2	6.1	10.1	17.8
E-13	3.6	6.2	11.3	17.0
S-6	4.4	6.6	13.7	21.4
S-8	3.0	8.8-	16.2	27.3
S-9	4.3	[illegible]	17.9	20.9
S-12	2.3	3.4	10.6	16.2
S-13	3.1	7.1	10.9	16.9
S-14	4.0	6.8	10.4	17.0
S-15	2.4	6.1	9.9	17.1

[illegible] 1930.—Concrete [illegible].

[illegible] on Plain [illegible].

Gage line	30,000	45,000	60,000	75,000
S-16	1.9	3.5	4.9	6.3
S-17	[illegible]	[illegible]	[illegible]	[illegible]
S-18	4.6	7.1	[illegible]	[illegible]
S-19	3.7	4.3	[illegible]	16.6
S-20	3.0	[illegible]	[illegible]	16.3
S-22	5.2	6.7	11.4	[illegible]
S-23	[illegible]	[illegible]	[illegible]	[illegible]
S-24	[illegible]	[illegible]	[illegible]	[illegible]
S-25	1.6	2.6	2.4	4.1
S-27	[illegible]	[illegible]	[illegible]	[illegible]
S-28	[illegible]	7.1	11.2	15.1
S-29	[illegible]	[illegible]	[illegible]	[illegible]
S-30	6.0	[illegible]	[illegible]	[illegible]
S-31	[illegible]	[illegible]	[illegible]	[illegible]
S-32	4.9	8.4	13.7	19.8
S-34	[illegible]	5.2	8.3	9.9
S-35	[illegible]	−1.7	[illegible]	[illegible]
S-A	6.9	14.7	[illegible]	[illegible]
S-D	[illegible]	[illegible]	[illegible]	[illegible]
W-6	4.1	[illegible]	[illegible]	[illegible]
W-7	4.9	8.7	18.4	26.7
W-8	[illegible]	[illegible]	14.5	21.0
W-9	[illegible]	[illegible]	[illegible]	[illegible]
W-10	[illegible]	[illegible]	15.6	23.4
W-11	[illegible]	[illegible]	[illegible]	[illegible]

Slab # [illegible] — CONCRETE [illegible].

Bonds in Slab in Pounds.

Gage line	30,000	45,000	[illegible]	[illegible]
N-12	4.9	11.5	19.4	26.8
N-13	4.2	10.3	[illegible]	[illegible]
N-14	4.6	[illegible]	15.8	21.6
N-15	5.0	9.7	14.[illegible]	20.0
N-A	6.5	14.[illegible]	19.[illegible]	24.4
N-B	5.5	7.9	[illegible].4	[illegible].4
N-C	.6	[illegible].2	[illegible].5	[illegible].5
N-D	5.6	1.6	−0.4	−[illegible].1
NE-H	4.7	11.7	16.0	20.0
NE-K	[illegible].6	16.9	[illegible]	[illegible]1.5
NE-C	5.1	7.[illegible]	14.4	19.[illegible]
NE-J	6.8	13.[illegible]	14.[illegible]	16.4
NE-S	0.1	−0.5	4.6	13.0
SE-I	3.6	5.1	12.3	[illegible].4
SE-Q	1.9	3.5	6.1	8.7
SE-R	3.5	4.4	7.5	11.2
SE-S	2.6	6.7	13.0	21.7
SW-R	0.4	3.5	5.7	7.8
SW-S	−1.[illegible]	[illegible].0	10.5	16.2
NW-Q	−[illegible].1	2.5	[illegible].1	7.2
NW-R	−[illegible].4	[illegible].2	5.6	[illegible].3
NW-S	7.1	[illegible].3	[illegible].1	18.1
N-A2	[illegible].5	15.3	15.3	18.0
N-A3	5.7	[illegible].9	8.1	9.0
E-A1	[illegible].9	[illegible].9	[illegible].7	54.0

[illegible]

[illegible]

Gage line	[illegible]	[illegible]	[illegible]	[illegible]
E-A2	5.1	17.1	[illegible]	[illegible]
E-A3	5.7	2.7	7.5	,7.5
S-A1	7.5	45.3	[illegible]	76.6
S-A2	[illegible]	14.1	14.7	[illegible]
S-A3	[illegible]	5.7	[illegible]	9.0
W-A1	5.7	[illegible]	[illegible]	[illegible]
W-A2	[illegible]	[illegible]	[illegible]	18.9
W-A3	1.1	4.7	[illegible]	[illegible]

SLAB # 1276-- STEEL ATTACHED.

Loads on Slab in Pounds.

Gage Line	30,000	45,000	[illegible]	75,000
N-6	2.4	13.4	[illegible].4	[illegible].3
N-8	3.6	11.6	28.1	[illegible].6
N-9	1.6	6.6	[illegible].5	[illegible].7
N-12	[illegible].2	9.6	22.4	[illegible].0
N-13	2.2	9.3	[illegible].0	[illegible].1
N-15	[illegible].6	8.5	20.9	34.8
N-A	6.5	18.0	24.0	[illegible].3
N-B	1.5	10.2	[illegible].4	[illegible].1
N-C	1.6	[illegible].1-	[illegible].3	[illegible].3
N-D	—0.6	2.6	[illegible].5	[illegible]/4
E-6	4.9	[illegible].3	[illegible].3	[illegible].1
E-8	[illegible].3	[illegible]5.7	[illegible].0	58.0
E-9	[illegible].1	11.9	[illegible].9	[illegible].9
E-12	5.0	[illegible]7.7	[illegible].3	[illegible].3
S-6	3.1	[illegible]6.3-	[illegible]4.3	62.8
S-8	[illegible].3	13.6	26.5	55.6
S-9	3.5	13.6	[illegible].6	27.4
S-12	5.0	12.0	[illegible].1	42.7
S-13	0.5	11.3	[illegible]9.3	[illegible].9
S-19	[illegible].3	[illegible].3	[illegible].9	[illegible].6
S-20	[illegible].2	[illegible].3	[illegible].3	[illegible].7
S-21.	3.4	14.7	[illegible].7	[illegible].0
S-22	3.0	[illegible].0	22.6	[illegible].3
S-23	1.4	[illegible].5	[illegible].5	[illegible].3
S-26	1.9	4.0	7.5	10.9

SLAB # 1256-- STEEL STRESSES.

Loads on Slab in Pounds.

Gage line	30,000	45,000	60,000	75,000
S-27	-0.4	2.6	[illegible]	14.6
S-28	0.7	6.0	[illegible]	[illegible]
S-29	[illegible]	11.6	28.1	41.1
S-30	2.9	13.4	[illegible]	[illegible]
S-33	2.[illegible]	7.2	[illegible]	[illegible]
S-34	2.0	5.7	14.4	[illegible]
S-35	-1.9	-1.4	1.0	10.7
S-A	5.4	15.4	20.7	[illegible]
S-B	1.4	[illegible]	[illegible]	[illegible]
S-C	0.9	[illegible]	15.1	[illegible]
W-1	1.1	0.6	24.5	[illegible]
W-2	0.2	-0.6	25.0	36.9
W-3	0.2	2.3	[illegible]	[illegible]
W-4	1.0	1.5	[illegible]	[illegible]
W-5	0.3	[illegible]	[illegible]	36.5
W-6	2.6	[illegible]	31.1	43.3
W-7	4.8	14.6	30.6	[illegible]
W-8	4.5	16.5	31.0	[illegible]
W-9	1.9	13.6	[illegible]	40.6-
W-10	[illegible]	15.6	[illegible]	47.0
W-11	2.7	12.6	[illegible]	[illegible]
W-12	[illegible]	14.7	[illegible]	[illegible]
W-13	[illegible]	17.9	28.6	[illegible]
W-14	[illegible]	22.7	[illegible]	[illegible]
NE -M	5.1	17.3	25.4	40.0

Class A [illegible]

Loads on Slab in Pounds.

Case line	30,000	45,000	60,000	75,000
NE-N	4.1	16.1	37.7	92.7
NE-O	4.2	17.8	37.1	57.4
NE-P	6.3	23.4	40.1	56.8
NE-Q	−1.2	2.7	12.2	18.1
NE-R	3.0	6.5	15.0	16.3
SE-M	5.9	17.9	24.9	37.7
SE-N	8.0	16.0	37.0	51.8
SE-O	2.5-	16.5	31.5	54.8
SE-P	4.3	17.7	30.3	44.5
SE-Q	−2.5	0.9	8.5	15.7
SE-R	−0.5	3.4	9.0	18.1
SE-S	−2.3	6.1	16.8	27.8
SW-M	5.3	18.0	27.3	34.8
SW-N	0.6	11.3	25.6	49.6
SW-O	4.1	19.8	32.2	54.6
SW-P	4.7	16.4	20.3	47.6
SW-Q	−0.7	5.9	13.9	20.6
SW-R	0.2	5.8	13.3	18.0
SW-S	−0.2	8.4	16.0	27.6
NW-M	4.9	20.4	30.1	39.2
NW-N	6.0	20.8	31.6	41.6
NW-O	2.8	11.2	24.1	42.9
NW-P	4.9	21.3	30.7	41.0
NW-Q	−4.0	−1.7	7.8	16.0
NW-R	−0.8	1.8	11.9	18.0
NW-S	0.7	7.5	18.7	31.2

TAB[illegible] DATA. SLAB [illegible]

One Unit equals 1,000 lb. per sq. in. Unit Stress in the Steel.

One Unit equals 1000/n lb. per sq. in Unit Stress in Concrete.

"n" equals the ratio of the moduli of steel to concrete

Load on Slab in Pounds.-Concrete Stresses.

Gage line	30000	45000	60000
N-4	3.4	7.9	15.[illegible]
N-5	1.0	6.6	16.1
N-6	3.7	5.9	11.4
N-7	0.9	4.2	6.7
N-8	3.1	3.5	6.0
N-D	4.9	11.9	11.0
N-E	4.3	11.3	14.3
N-F	0.1	3.2	6.2
N-G	- 2.5	-2.3	- 3.3
E-4	2.5	9.6	18.3
E-6	7.3	21.6	30.6
S-4	0.2	5.6	12.1
S-6	3.3	17.2	23.7
W-4	3.2	8.2	12.7
W-6	3.4	8.4	14.9

SLAB # 1257 STEEL STRESSES.

Load on Slab in Pounds.

Gage line	30000	45000	60000
N-1	3.0	2.0	23.5
N-2	1.6	1.6	23.0
N-3	2.1	6.3	25.0
N-4	5.8	18.5	23.2
N-5	6.8	21.0	33.1
N-6	4.4	17.3	26.7
N-A	2.3	5.2	27.1
N-B	3.3	11.2	26.5
N-C	6.0	23.1	27.2
N-D	7.6	20.2	27.3
E-4	1.9	14.2	32.1
E-6	5.7	28.0	35.9
S-4	1.1	10.4	29.7
S-6	6.4	26.3	34.9
W-4	6.2	18.7	29.8
W-6	9.0	24.0	34.0

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